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**DEPARTMENT OF TRANSPORTATION**

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# Broad Street Line Extension to the Philadelphia Navy Yard – Phase 2 Feasibility Study

**Final Report**

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PREPARED FOR

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# EXECUTIVE SUMMARY

The Pennsylvania Department of Transportation (PennDOT) Bureau of Public Transportation (BPT) and the Southeastern Pennsylvania Transportation Authority (SEPTA) have completed the **Broad Street Line Extension to the Philadelphia Navy Yard** Phase 2 feasibility study (BSLX), with this report evaluating the potential to expand transit connectivity beyond the current terminus of the SEPTA Broad Street Subway Line (BSL) at NRG Station south into The Navy Yard. This report examines potential subway alignments, constructability issues and ridership analysis, with a focus on how those issues would impact the ability of the project to be eligible for the FTA New Starts Program. In addition, a series of immediate, short and medium term transit connectivity improvements are identified, analyzed and recommended.

The alternatives development and evaluation process was responsive to the defined Purpose and Need (P&N), acknowledging that the planned growth of The Navy Yard would increase demand for transit service to/from and within the study area. This demand would not be met because of the limitations of the existing transportation infrastructure and the deficiencies in current transit service. Specifically, the need for increased transit service has three components:

1. The need for transit service to better serve existing patrons and accommodate new patrons;
2. The need for better transit service to maximize and maintain The Navy Yard's growth potential; and,
3. The need for transit service to enhance and support sustainability plans.

The following project goals and objectives were identified to complement its Purpose and Need:

1. Socio-economic – to ensure a ladder of opportunity to provide access to investments in The Navy Yard.
2. Economic Development – to enable economic development by leveraging past and future investments in The Navy Yard.
3. Environmental – to advance the joint sustainability agenda of the City of Philadelphia and SEPTA.
4. Cost Effectiveness – to implement a cost-effective and financially feasible rapid transit link to The Navy Yard.
5. Mobility Improvement – to increase mobility between The Navy Yard and the Philadelphia region.

Following a series of meetings with the key stakeholders, **three subway extension alternatives** and **three enhanced bus scenarios** were identified for further evaluation. All alternatives assumed a 2040 horizon year.

### 2040 BUILD ALTERNATIVE 1: ROUSE BOULEVARD ALIGNMENT

Alignment 1 consists of an extension to a single station proposed near Central Green. It begins at NRG Station and follows south along Broad Street to its intersection with League Island Boulevard. The subway extension route then follows Rouse Boulevard until reaching the proposed station near Central Green. The Rouse Boulevard alignment is the shortest route among the conceptual alignments.

#### 2040 BUILD ALTERNATIVE 2: 13TH STREET AND CONSTITUTION AVENUE ALIGNMENT

The Alignment 2 extension consists of two stations. The subway extension route begins at NRG Station and follows south along Broad Street into The Navy Yard towards 13th Street and then Kitty Hawk Avenue. The first station along this alignment is proposed near the intersection of 13th Street and Intrepid Avenue, with the terminus station on Kitty Hawk Avenue.

#### 2040 BUILD ALTERNATIVE 3: BROAD STREET AND KITTY HAWK AVENUE ALIGNMENT

The Alignment 3 also consists of two stations. The subway extension route begins at NRG Station and continues south along Broad Street to Kitty Hawk Avenue. The first proposed station along this route is located along Broad Street by the Marine Parade Grounds. The route then turns east on Kitty Hawk Avenue and follows the road to its proposed terminus station east of League Island Boulevard.

#### 2040 BUILD ALTERNATIVE 4: LOOP

Alternative 4 enhances the existing Loop shuttle bus service by greatly increasing service frequency and service hours. It discontinues the existing Express shuttle service. It assumes no change to subway service, with BSL terminating at NRG Station. Though Alternative 4 as analyzed in this report assumed that the existing express bus service would be discontinued, based on feedback from the public open house it is recommended that the express bus service be maintained with the implementation of the enhanced loop shuttles proposed for Alternative 4.

#### 2040 BUILD ALTERNATIVE 5: EXPRESS & LOOP

Alternative 5 also enhances the existing Loop shuttle bus service by increasing service frequency and service hours. However, it also includes an enhanced Express shuttle connecting Center City to/from The Navy Yard via I-95. No change to heavy rail service.

#### 2040 BUILD ALTERNATIVE 6: ROUTE 45 & LOOP

Alternative 6 extends every SEPTA Route 45 bus route run to The Navy Yard. The existing Express shuttle service is discontinued. The West Loop shuttle is enhanced by increasing its service frequency and service hours, and Loop East is discontinued. No change to heavy rail service.

An order of magnitude capital cost estimate was developed for the subway options based on the conceptual level engineering drawings that relied on preliminary alignment profiles and conceptual constructability analysis, including soil conditions. The capital cost estimates range from $984 million for Alternative 1 to $1.82 billion for Alternative 3 (in current year dollars). The operating plans were developed to determine the incremental O&M costs of all six scenarios, and to serve as inputs into the travel demand model to forecast ridership potential. The resulting ridership forecasts indicate that - in comparison to the 2040 No Build scenario - the 2040 Build subway enhancements could attract a total of 4,600 to 5,100 additional new riders while the bus scenarios would add anywhere from 1,600 to 2,900 new passengers. Summary level details are shown in Table ES-1.

| Alternative | Total Daily Trips | New Linked Trips | Capital Cost Estimate (2018 $M) | Annual Oper. & Maint. Cost |
|---|---|---|---|---|
| **Heavy Rail:** | | | | |
| 1. Rouse Boulevard | 10,900 | 4,600 | $984 | $2.2 |
| 2. 13th Street & Constitution Ave | 11,400 | 5,100 | $1,708 | $3.4 |
| 3. Broad Street & Kitty Hawk Ave | 10,900 | 4,600 | $1,820 | $3.7 |
| **Enhanced Bus:** | | | | |
| 4. Loop | 8,900 | 2,600 | N/A | $1.5 |
| 5. Express & Loop | 9,200 | 2,900 | N/A | $2.9 |
| 6. Route 45 & Loop | 7,900 | 1,600 | N/A | $1.2 |

**Table ES-1: 2040 Ridership Projections and Cost Estimates**

Note: capital costs for the evaluated bus-only scenarios are negligible

The ridership and traffic volume output from the regional travel forecasting model and capital and O&M cost estimates for the identified scenarios were used to conduct the feasibility screening. The feasibility screening then focuses on whether the capital investment of intensive subway extension scenarios might be eligible for the Federal Transit Administration (FTA) New Starts Program, and whether the bus enhancements would meet SEPTA's own in-house performance rating criteria for service improvements.

Analysis completed for each of the Alternatives shows that improving transit access to The Navy Yard has a clear benefit and should be advanced. As The Navy Yard continues to grow and add employees and residents, they will need and want additional transit options. As such, we recommend a phased approach that focuses on growing transit options to The Navy Yard over time. To ensure that this phased approach continues to progress and be implemented, a working group comprised of SEPTA, PIDC and City officials should be formed to continue to discuss and advance each of these recommendations.

Based upon the anticipated ridership and traffic volumes, capital costs and O&M costs, the following recommendations are made to improve transit access to The Navy Yard:

**Immediate Term: Better Multimodal Access at NRG Station**

The current environment for riders to access the shuttles at NRG station could be vastly improved. The existing shuttle system has been proven to be very successful in accommodating transit riders, and with improved and easier access between SEPTA and the shuttles, ridership could further increase. We would recommend exploring the following:

- Dedicated curb space and pull-off areas for shuttle buses near station exits
- Enhanced shuttle signage within and around NRG station
- Opportunity for cross-promotion of SEPTA and Navy Yard Shuttle services

- With the recent addition of Indego to NRG station, better connection of bike and pedestrian facilities between NRG station and The Navy Yard will improve safety and mobility
- Provisions of better amenities at bus stops adjacent to NRG station

**Short Term: Enhanced Shuttle Frequency at Jefferson Station and NRG Station**

The results of this study indicate that improving bus access to The Navy Yard would be a viable and cost-effective solution to meet the project's Purpose and Need, serving to alleviate existing bus crowding as well as some traffic congestion experienced in The Navy Yard today. The shuttles currently run by the Philadelphia Industrial Development Corporation (PIDC) are very successful, showing a clear desire for Navy Yard employees to continue to utilize transit to access the area.

Based upon an analysis of the three bus alternatives and comparing them to SEPTA's own current service standards, Alternative 4, which proposed a bus headway of 7 minutes to meet most BSL trains, was identified as the most cost-effective bus scenario in terms of benefits relative to the operating costs. As a result, it is recommended to advance this alternative for additional route planning and study. This can be further supported with SEPTA support to the proposed Navy Yard TMA.

**Medium Term: Incremental Growth of Shuttle/Bus Access to The Navy Yard**

As shuttle service frequency is increased and transit ridership continues to grow, additional analysis should be undertaken regularly to assess service to see if additional shuttle growth in terms of frequency, areas served, additional shuttle origins, or hours of service should be increased further beyond the recommended Alternative 4. Additionally, as the ridership of the shuttle system increases, the potential for SEPTA to take over operation should be regularly assessed.

To prepare for the point in time when demand exceeds the capacity of the shuttle system, even with more vehicles and higher frequencies, it is recommended that feasibility studies of additional modes such as Bus Rapid Transit and Light Rail be explored to serve The Navy Yard, Stadium area, FDR Park and adjacent residential areas.

Based on feedback received during the public open house it is recommended that the existing express bus service between The Navy Yard and Center City be continued in conjunction with the improved bus loops proposed with Alternative 4. This scenario was not included in the ridership projections and was therefore not considered in this study.

**Long Term: Broad Street Subway Extension**

As The Navy Yard, as well as shuttle ridership continues to grow, more efficient modes of transit should continue to be pursued. Currently, the longer-term vision for The Navy Yard is primarily derived from The Navy Yard Master Plan, which is likely to be updated over the next few years. Using data from that plan, as well as the ridership and traffic volumes output from the regional travel forecasting model and capital

and O&M cost estimates for the identified scenarios, the potential for an extension of the Broad Street Line subway was further explored. A feasibility screening was completed, focusing on whether the capital investment intensive subway extension scenarios might be eligible for Federal Transit Administration (FTA) New Starts funding.

Without committing to a locally preferred alternative at this point, the preliminary New Starts analysis indicates that the subway extension scenarios are likely to obtain at least a favorable rating in the congestion relief, environmental benefits, and economic development project justification criteria. Alternative 1 would likely receive the highest rating in categories of cost efficiency and mobility – a function of lower capital cost and relatively high ridership projections when compared to the other two alignments.

However, none of the three subway scenarios would obtain an overall Medium rating needed to seek admittance into the FTA New Starts funding program, based on the existing conditions within The Navy Yard. We recommend regularly revisiting the FTA New Starts Rating analysis as The Navy Yard continues to grow and as the transportation funding landscape changes. We would recommend revisiting the analysis if any of the following occur:

- Capital other than the FTA New Starts funds are available to advance the project;
- Changes in Federal programs from the current (2018) FTA Processes;
- Significant changes in development (population or employment) in The Navy Yard; or
- Significant changes to The Navy Yard Master Plan.

It is important to note that the planned growth of the Navy Yard used in this analysis is based on the 2013 Master Plan, which is low density and conservatively assumes that there will not be heavy rail at the Navy Yard. Were there to be an extension of the Broad Street Line, the 2013 Master Plan assumes that surface parking lots would ultimately convert to building sites, allowing for far more density, though this is not depicted.

# 1 INTRODUCTION

The Pennsylvania Department of Transportation (PennDOT) Bureau of Public Transportation (BPT) and the Southeastern Pennsylvania Transportation Authority (SEPTA) have requested assistance to develop a Phase II study for expansion of transit connectivity beyond the current terminus of the SEPTA Broad Street Subway Line (BSL) at NRG Station south into the Philadelphia Navy Yard.

There is a long history in the Philadelphia region of attempting to extend the BSL to The Navy Yard. In 1966, the City of Philadelphia commissioned a study to examine the potential of extending the Subway Line from the newly planned Pattison Avenue station into The Navy Yard, which was then an active military base with tens of thousands of employees. That study found the project to be feasible, with minor challenges. However, due to U.S. military engagements abroad and the ongoing Cold War, the $14.5 million extension was never built. Since that time, several studies have been conducted with a similar scope, including one most recently in 2008.

The Philadelphia Navy Yard dates to 1776 when the Continental Congress leased land along the Front Street docks for the development of the country's Navy. As the Philadelphia shipbuilding industry grew, operations were moved to the current location on League Island around the time of the Civil War. Between 1876 and 1996, 53 new warships were constructed, and 1,218 ships were repaired on site, and it employed over 40,000 people at its peak production during World War II. The site was then designated for closure under the Defense Base Realignment and Closure Act of 1990 (BRAC), and operations at The Navy Base ceased in 1991 with the shipyard following soon after in 1996.

In March 2000, the Philadelphia Authority for Industrial Development (PAID) acquired approximately 1,200 acres at the site of the former U.S. Navy Yard from the federal government. The Philadelphia Industrial Development Corporation (PIDC), a private, not-for-profit corporation created to promote economic development and job creation throughout the city, manages the planning, development and operation of real estate assets on behalf of PAID and the City of Philadelphia.

Once acquired, the 2004 Philadelphia Navy Yard Master Plan was created to guide planning and investment decision-making through the proposals of new conceptual designs and infrastructure improvements. Furthermore, transit options, including an extension of the Broad Street Line, were evaluated in how each could serve what was projected to be 30,000 employees and thousands of residents. Since 2004, The Navy Yard has established itself as a viable and attractive location, offering unique attributes for office space users, industrial enterprises, and collaborative academic, governmental and private research, particularly focused on the pharmaceutical, applied sciences and energy sectors. Due to The Navy Yard's extraordinary success, the 2013 Master Plan Update produced new projections for employment and residential data: nearly 3,000 residents and over 36,000 employees at full build-out.

This new study builds upon the findings of previously completed studies, primarily the *Broad Street Line Extension Feasibility Study*, published in 2008 and funded through the Delaware Valley Regional Planning Commission (DVRPC). This study identifies, screens, and evaluates alternative alignments, modes, and station locations within The Navy Yard without selecting a recommended Locally Preferred Alternative (LPA). The process aims for preliminary consistency with the Federal Transit Administration's (FTA) New Starts guidelines that enable fixed guideway projects to be eligible for federal funds.

This study analyzes heavy rail and bus service configurations for enhanced transit access to The Navy Yard (BSLX) by:

- **Identification of potential alternatives**
  Three potential subway alignments and associated station locations and three enhanced bus service scenarios were identified for screening and evaluation. The alternatives were chosen using project justification data containing population and employment data at the traffic analysis zone level (TAZ) for current year 2013 and horizon year 2040, location and magnitude of affordable housing, location and magnitude of transit-dependent populations, and supportive land use policies. For each subway alignment, vertical alignments (subsurface and at-grade) were evaluated.

- **Development of conceptual level engineering drawings and capital cost estimates**
  After collecting and reviewing GIS data and previous engineering studies within The Navy Yard from PIDC, conceptual level engineering drawings for track, power, and civil engineering were developed. Capital cost estimates have been developed based on the conceptual level engineering following the New Starts Cost Categories.

  In addition to the conceptual engineering drawings, review and evaluation of the preliminary alignment profiles based on existing available geological and geotechnical record information, summarizing likely soil conditions affecting alignment profiles and station locations, was performed.

- **High level feasibility screening of identified scenarios**

  The horizon year ridership and traffic volume outputs from the DVRPC travel forecasting model and capital and operating and maintenance (O&M) cost estimates for the identified potential alignments served as inputs to assess feasibility and make some determinations on whether the project might be eligible for FTA's New Starts funds. The DVRPC travel forecasting model was based upon DVRPC-approved projections for population and employment in The Navy Yard.

  The high-level screening investigated the scenarios' cost-effectiveness to increase transit accessibility, potential to improve area mobility, increase transit ridership, improve air quality, ensure fair distribution of transit services, and support opportunities for economic development.

This report identifies and compares the costs, benefits, and impacts of a range of alternative options for improving transit connectivity between the BSL's current terminus at NRG Station and The Navy Yard. It documents the alternative identification process without selecting and committing to a LPA. The high-level scenario evaluation considers environmental and constructability concerns, overall regional cost to benefit, and input from multiple stakeholders. If a determination is made to begin the process to advance towards construction of an extension of the BSL into The Navy Yard in the future, the findings of this report will identify planning tasks that would need to be completed prior to Engineering to conform to FTA's planning and project development guidelines.

# 2 PROJECT BACKGROUND

## 2.1 STUDY AREA

The Navy Yard is situated in a strategic location halfway between New York and the District of Columbia along Interstate 95, approximately 3.5 miles south of Center City Philadelphia, at the terminus of historic Broad Street. Since 2000 the 1,200 acres site has been managed as a mixed-use business and industrial park by the PIDC. Having been decommissioned as an active US naval facility in 1995, The Navy Yard has seen significant change with the addition of about 11,000 jobs at 145 companies occupying almost 7 million square feet of new and renovated office and industrial space (www.NavyYard.org).

Major employers occupying The Navy Yard area (as large as Center City Philadelphia) include Urban Outfitters, Inc., Tasty Baking Company, Iroko Pharmaceuticals, Philly Shipyard, and the U.S. Navy. The Navy Yard is divided into five districts: Historic Core, Central Green, Mustin Park, Canal, and Port (Figure 1).


Figure 1 - Study Area

## 2.2 LAND USE ANALYSIS

Existing land uses in The Navy Yard are primarily industrial and commercial, with some recreational, open space, and vacant areas. In 2004 the PIDC developed a Master Plan for The Navy Yard and then updated the plan in 2013. The current version identifies six districts with future residential development within existing commercial areas, conversion of vacant properties to industrial use, and additional recreation and open space. The Master Plan includes zoning and guidelines for establishing infrastructure needed to support the projected employment at buildout of 36,364 and the construction of over 1,000 residential dwelling units. Figure 2 illustrates current land uses by type in The Navy Yard, while Figure 3 illustrates proposed development in The Navy Yard by 2040, according to *The Navy Yard 2013 Master Plan Update*.

Philadelphia has several policies that support high-density, mixed-use, transit-friendly residential and commercial land development, including the Philadelphia2035 Citywide Vision, the Philadelphia Complete Streets Design Handbook, and the City of Philadelphia Green Streets Design Manual.

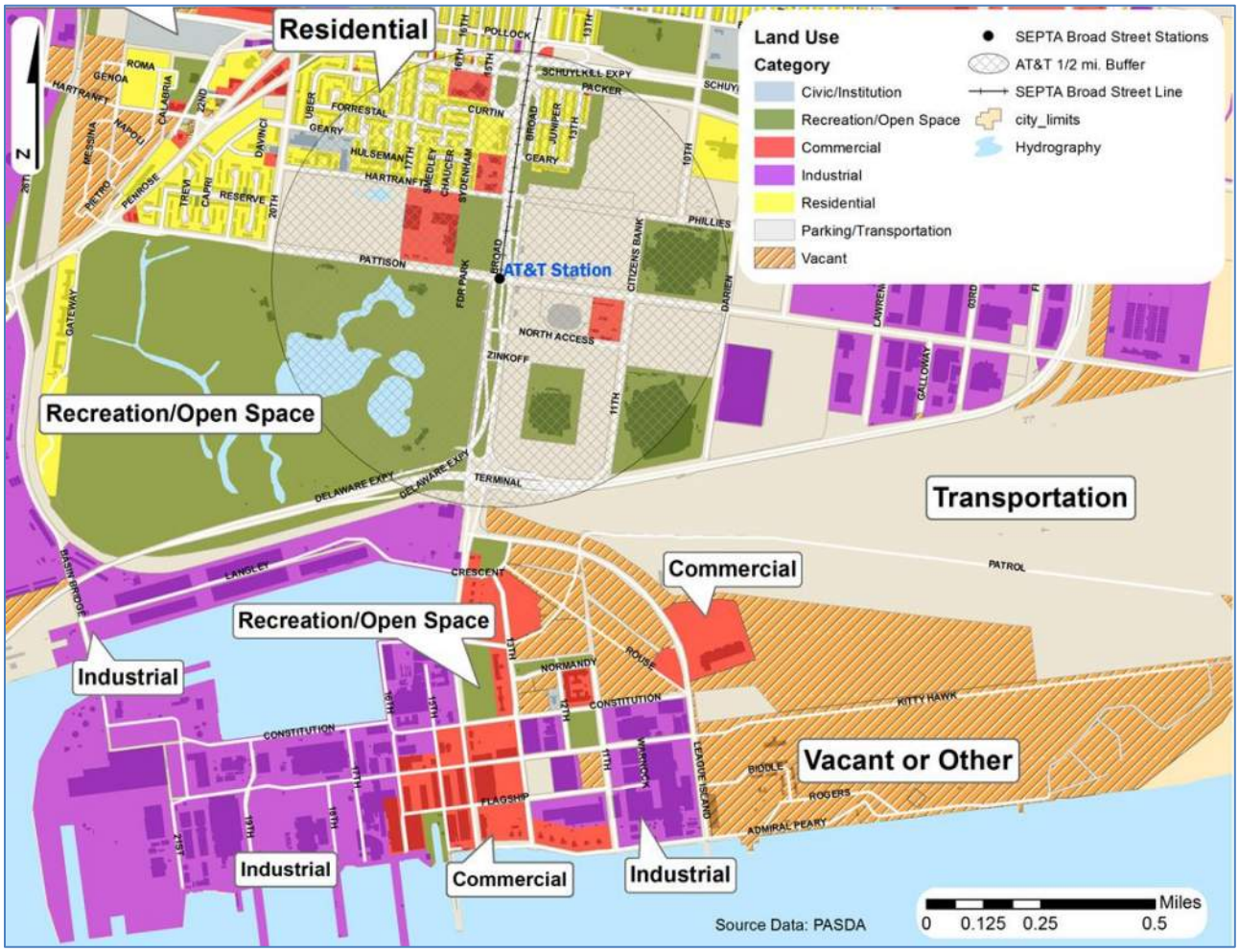


**Figure 2: Existing Navy Yard Land Uses**


**Figure 3: Proposed 2040 Navy Yard Development**

Source: *The Navy Yard 2013 Master Plan Update*

## 2.2 PRELIMINARY ENVIRONMENTAL SCREENING

A Preliminary Environmental Screening was conducted in June 2015 by Michael Baker, Inc. The study area included portions of Broad Street in south Philadelphia, the Stadium district, and The Navy Yard as illustrated in Figure 4.

The preliminary screening revealed the following results:

- Coordination with PA Game Commission (PGC), PA Dept. of Conservation & Natural Resources (DCNR), and PA Fish & Boat Commission (PFBC) required for total of eight Threatened & Endangered species.
- Project area south of Delaware Expressway is within 1-percent-annual-chance floodplain as well as Dept. of Environmental Protection (DEP) Coastal Zone management area.
- Sole source aquifer underlies entire project area.
- Known and unknown Hazardous Waste contaminant areas located within project area.
- Coordination with PA Historical & Museum Commission (PHMC) required for six historic resources listed on the National Register of Historic Places.
- Multiple wetland areas exist between Rail Yard and Kitty Hawk Avenue.
- Coordination with PFBC, US Army Corps. of Engineers (USACE), and US Coast Guard required for Delaware Estuary listed as a Navigable Waterway.

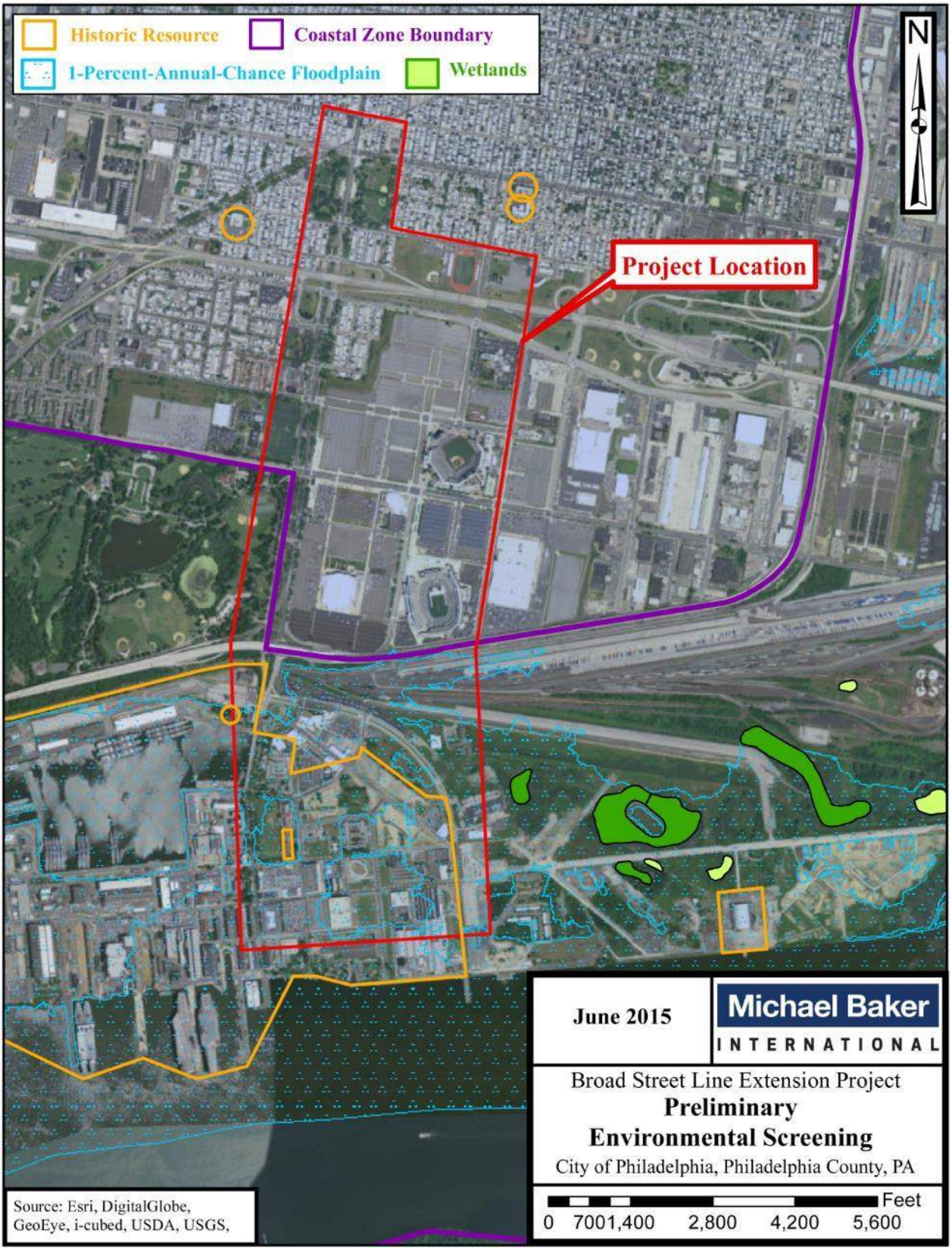


Figure 4: Map of Preliminary Environmental Screening

## 2.3 EXISTING TRANSIT SERVICE

There is currently no passenger rail access to The Navy Yard. The nearest station, NRG Station on the Broad Street Line, is nearly a mile from The Navy Yard's entrance. The BSL operates between the Fern Rock Transportation Center in North Philadelphia and NRG Station. Connections to SEPTA's regional rail and Amtrak are available at 30th Street Station, City Hall Station and Jefferson Station via transfer to the Market-Frankford Line or the trolley lines.

Subway trains operate with headways of eight minutes or less from 5:00 am to 6:10 pm, and 10 to 12 minutes until service ends at midnight. From midnight to 5:00 am, bus service is used instead of heavy rail service. The Broad Street Line subway runs 24 hours during the weekends. Figure 5 shows a map of the Broad Street Line subway.


Figure 5: Broad Street Line Subway Map

To provide access to The Navy Yard, the PIDC, through a contract with Krapf Coaches, initiated the Center City Express and The Navy Yard Loop shuttle services in December 2012 (shown in Figure 6). These routes serve as the primary transit linkages to The Navy Yard and offer transportation alternatives for employees and visitors who prefer not to drive to The Navy Yard. The free bus shuttles are consistent with goals for environmentally sustainable development and expanded transit services discussed in *The Navy Yard 2013 Master Plan Update* issued by the PIDC.


**Figure 6: PIDC Shuttle Routes**

The Navy Yard Loop replaced a discountinued SEPTA Route 71 that linked NRG Station on SEPTA's Broad Street Line with The Navy Yard. The Navy Yard Loop operates from 5:30 am to 7:30 pm on 20-minute headways and connects NRG Station with six locations within The Navy Yard. Additional flag stops have been established across The Navy Yard.

The Express shuttle service from Philadelphia City Center, also known as the City Center Express, operates from 6:15 am to 10:41 am and from 2:30 pm to 7:50 pm on 10 to 20-minute headways. The City Center Express operates from 10th Street between Market and Filbert Street (Jefferson Station) to five bus stops within The Navy Yard development and additional flag stops only.

Ridership has grown since the initiation of the two bus shuttle services; from approximately 500 total daily trips on both shuttles at the end of 2012, doubling by April 2013, and reaching average daily ridership of over 1,150 trips in April 2014, and over 1,250 by August 2014. This has led to an introduction of an additional counterclockwise Loop service (in addition to the shuttle's clockwise loop around The Navy Yard).

On the weekends, SEPTA supplements PIDC service to The Navy Yard with Bus Route 17 that connects Center City to The Navy Yard via NRG Station. Service operates from The Navy Yard from approximately 7:00 am to 7:00 pm with hourly headways. Travel times from Center City to The Navy Yard on this limited, weekend service are approximately 40 minutes. Figure 7 shows Route 17 alignment within The Navy Yard.

Current level of bus transit service provision to/from The Navy Yard is shown in Table 1.


**Figure 7: SEPTA Bus Route 17 Weekend Service to Navy Yard**

| Route | Service Span | | | Service Frequency | |
|---|---|---|---|---|---|
| | Weekday | Saturday | Sunday | Headways | Daily Runs |
| **Express** | 6:30AM - 7:30PM | N/A | N/A | 22 mins | 38 |
| **Loop** | 5:30AM - 7:30PM | N/A | N/A | 5 mins peak to 35 mins off-peak | 36 |
| **Route 17** (weekends only) | N/A | 6:30AM - 6:30PM | 6:30AM - 6:30PM | 60 mins | 13 |

Table 1: Existing Bus Service in The Navy Yard

## 2.3 PREVIOUS STUDIES AND RECOMMENDATIONS

Improved transit and enhanced connectivity to/from The Navy Yard has been studied for decades, beginning with the 1966 study commissioned by the City of Philadelphia to examine the potential of extending the Broad Street Line from the newly planned Pattison Avenue Station (renamed since as AT&T and now NRG Station) into The Navy Yard.

In 2004, the PIDC developed the first master plan for The Navy Yard. *The 2004 Philadelphia Navy Yard Master Plan* examined enhanced transit alternatives to/from The Navy Yard. Short term, it recommended immediate improvements to bus service between The Navy Yard and the Broad Street Subway. In addition, the Plan called for a future one-mile extension of the SEPTA Broad Street Subway line, bringing heavy rail transit to The Navy Yard from NRG Station, at the then estimated cost of $260 million.

Following up on the 2004 master plan recommendations, in 2008, Parsons Brinckerhoff, on behalf of the City of Philadelphia, SEPTA, DVRPC, and the PIDC, released the 2008 *Broad Street Line (BSL) Extension Feasibility Study* evaluating the technical feasibility of construction of a subway extension to The Navy Yard and estimated capital costs, ridership, and expected economic impacts. Four potential alignments were studied, including the preferred alternative highlighted in Figure 8. The study compared the costs and benefits of an extension of the Broad Street Line subway to the costs and benefits of two bus-based scenarios (an existing bus service alternative and an enhanced bus service alternative). The study concluded it would be feasible and preferable to construct the 1.5-mile tunneled subway extension into The Navy Yard with two new stations. The study projected 8,100 daily boardings in 2040 at the two new stations in The Navy Yard. The recommended heavy rail extension would support "greater residential and commercial uses in a transit supportive manner at a cost of approximately $370 million (in 2008 dollars)." Those original capital cost estimates were updated by PIDC in 2014, concluding that the capital cost in 2015 dollars would exceed $435 million.

Due to significant development within The Navy Yard and to better reflect existing and future land use patterns, the 2004 site master plan was updated in 2013. The current version, *The Navy Yard Master Plan 2013 Update*, identified six districts emphasizing different mixes of commercial, office, industrial, and residential development. The plan included zoning and guidelines for building types and massing, vehicular, pedestrian, and bicycling networks, open space, stormwater management, energy production

and distribution, and the construction of over 1,000 residential dwelling units for 3,000 future residents. The projected employment within The Navy Yard at buildout was over 36,000.

The 2013 Master Plan noted that previous studies, including the 2008 feasibility analysis, recommended extending the Broad Street Line to The Navy Yard. The PIDC plan supported the recommendation, concluding that "the Broad Street Line Extension will leverage, catalyze, and greatly enhance the development potential of the entire Navy Yard." The plan noted the positive impact the subway expansion would have on the area's land values and the potential for high-density development opportunities within walkable distance to the potential one or two subway stations.

The 2008 *Broad Street Line (BSL) Extension Feasibility Study* relied on the initial 2004 master plan to support much of its analysis. This Phase 2 study builds upon the 2008 recommendations to evaluate the technical and financial feasibility of construction of a BSL extension to The Navy Yard but integrates significant changes from the 2004 to 2013 master plan in its baseline and horizon year analysis - with revised employment and population projections at full buildout, and updated capital, operating and maintenance costs based on current unit costs and conditions.

This Phase 2 feasibility analysis also acknowledges recent studies that considered improved and/or new bus service as an option to enhance access and facilitate better connection to/from The Navy Yard. The Navy Yard *Transportation Access Improvement Study* (2014) built upon the *Evaluation of Bus Service Needs at The Navy Yard* (2013) that recommended introducing new fixed route bus services to enhance the transit linkages between The Navy Yard and the rest of the city – resulting in introduction of the two PIDC bus shuttle services at the end of 2013. The *Transportation Access Improvement Study* noted the new shuttles have been successful in attracting riders and that transit demand in The Navy Yard might soon outstrip transit supply: "bus transit has been successfully adopted by employees and customer at The Navy Yard and ridership is nearing, and some cases exceeding, the available capacity. Continued demand for The Navy Yard Shuttles at their present service levels threaten to result in significant overcrowding – with the real possibility that the appeal of the services could be diminished as demand exceeds capacity at peak times."

The study recommended short-term (0-2 years), mid-term (2-5 years), and long-term (5 plus years) changes for the new shuttle service to remain viable. In the short-term, there should be changes made to peak-period scheduling, an additional fourth bus added to the Express fleet, and an added stop in Old City. Mid-term recommendations included upgrading the shuttles to articulated buses to increase capacity, adding Center City West service (Figure 9), and transitioning to a SEPTA-run Express shuttle service with negotiated PIDC subsidy payments. Long-term recommendations included a BRT service to replace the Express shuttle and as an alternative to the subway extension

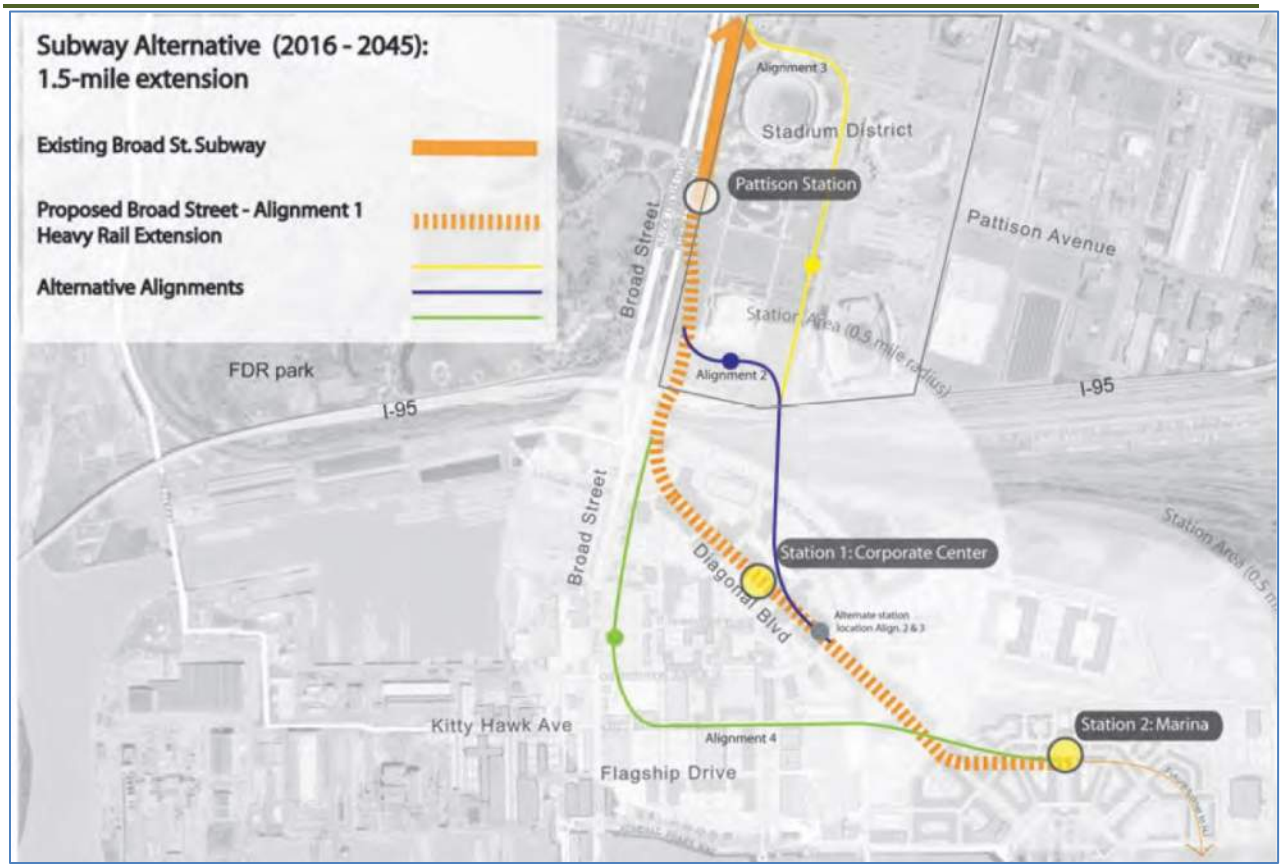


Figure 8 - Potential Subway Extension Alignments (The Broad Street Line Extension Feasibility Study, 2008*)

* Diagonal Boulevard has since been renamed Rouse Boulevard

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Figure 9 - Potential Center City West Route (The Navy Yard Transportation Access Improvement Study, 2014)

# 3 PROJECT PURPOSE & NEED

This chapter establishes the Purpose and Need (P&N) for the feasibility study and identifies related project goals and objectives. The P&N statement outlines both the reasons for considering a project and the underlying need for the project.

## 3.1 PROJECT PURPOSE

While the location of The Navy Yard 3.5 miles south of Center City Philadelphia makes it attractive for development, the site has impediments to achieving optimal growth, including limited access and limited parking supply. The Broad Street Line Extension (BSLX), would improve transit connectivity and increase opportunities for mobility between The Navy Yard, Center City Philadelphia, and the greater Philadelphia region. The purpose of the project is to:

- Advance the goals of recently adopted local and regional land use, transportation, and economic development plans.
- Provide a direct connection to/from The Navy Yard to Center City, the heart of the region's transportation network to benefit Philadelphia region's jobs, residents, and transportation infrastructure.
- Leverage public transportation to develop The Navy Yard to reach its full potential as a mixed-use residential and commercial center.
- Capitalize on the public/private investment of greater than $1 billion in creating a major economic development center.
- Provide high capacity public transportation to serve a dense, urban development with access limited by physical and geographical constraints.

The project purpose stems from increased transit demand due to current and future employment and population growth, lack of transit connections to The Navy Yard, parking supply issues related to future development, and sustainability goals/measures in adopted plans.

### POPULATION AND EMPLOYMENT GROWTH

The need for enhanced transit service is driven primarily by continued employment growth in The Navy Yard. There are over 11,000 employees currently working in The Navy Yard. As shown in Table 2, *The Navy Yard Master Plan 2013 Update* forecasts over 36,000 employees at full build-out in 2040, an increase of over 225% from current levels. While today the only residents of The Navy Yard are a few Navy officers, negotiations are under way to revise the existing deed restriction which limits residential development at The Navy Yard. In doing so, the PIDC hopes to develop over 1,000 residential units for 3,000 residents.

It is important to note that the planned growth of the Navy Yard used in this analysis is based on the 2013 Master Plan, which is low density and conservatively assumes that there will not be heavy rail at the Navy Yard. Were there to be an extension of the Broad Street Line, the 2013 Master Plan assumes that surface parking lots would ultimately convert to building sites, allowing for far more density, though this is not depicted.

| | Central Green | Historic Core | Canal District | Mustin Park District | Port Expansion | Shipyard and Commerce Center | Totals |
|---|---|---|---|---|---|---|---|
| **Acres** | 72 | 194 | 38 | 81 | 192 | 623 | **1,200** |
| **Occupied (SF)** | 478,796 | 1,718,402 | - | 101,344 | 106,050 | 3,933,449 | **6,338,041** |
| **Future Renovations (SF)** | - | 1,352,380 | - | - | - | 332,185 | **1,684,565** |
| **New Construction (SF)** | 921,000 | 1,420,673 | 948,000 | 901,000 | 965,000 | 235,000 | **5,390,673** |
| **Total (SF)** | 1,399,796 | 4,491,455 | 948,000 | 1,002,344 | 1,071,050 | 4,500,634 | **13,413,279** |
| **Residential Units** | - | 1,018 | - | - | - | - | **1,018** |
| **Employment** | 5,599 | 17,392 | 3,792 | 4,009 | 1,071 | 4,501 | **36,364** |

**Table 2 – Navy Yard 2040 Build-out Projections**

Source: *The Navy Yard Master Plan 2013 Update*

## CURRENT COMMUTING PATTERNS

Due to a lack of direct public transit access to The Navy Yard, 80% of Navy Yard employees currently drive to work. According to the City of Philadelphia's *Lower South District Plan* adopted in 2012, the workforce generates 55 million vehicle miles traveled (VMT) per year. At the projected rate of growth, VMT would reach 90 million annually by 2022, and 138 million at full build-out of The Navy Yard.

As shown in Figure 10, many employees commuting to The Navy Yard reside in Philadelphia. Extending the Broad Street Line would provide more direct access for these employees, as well as connect The Navy Yard to the regional transportation system.

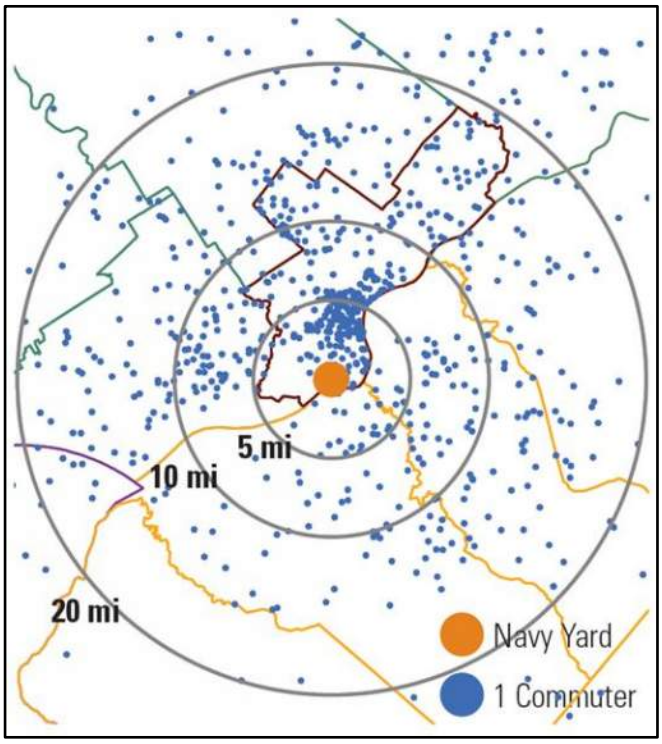



**Figure 10 - Navy Yard Commuting Distances**

Source: *Lower South District Plan*, 2012

## PARKING SUPPLY

Currently, over 6,400 cars commute to The Navy Yard each day. Based on current commuting patterns, without any new alternatives, the number of cars is projected to increase to 10,400 by 2022 and over 15,000 at full build-out.

Providing enough parking for over 15,000 cars would impede future development potential. Based on a survey from the 2012 Lower South Plan, most commuters would consider switching modes if the Broad Street Line was extended.

## 3.2 PROJECT NEED

With the planned growth of The Navy Yard, there is a demand for increased transit service to/from and within the study area. This demand is not met because of the limitations of the existing transportation infrastructure and the deficiencies in current transit service. Specifically, the need for increased transit service has three components:

1. The need for transit service to better serve existing patrons and accommodate new patrons;
2. The need for better transit service to maximize and maintain The Navy Yard's growth potential;
3. The need for transit service to enhance and support sustainability plans.

### NEED FOR TRANSIT SERVICE TO BETTER SERVE EXISTING PATRONS AND ACCOMMODATE NEW PATRONS

There is a limited supply of weekday transit service currently available for travel to and from The Navy Yard. The constraints of traffic congestion, inability to increase roadway capacity, as well as lack of parking supply limit the solutions that could address these needs. Commuters using rail or bus must transfer to the shuttles to reach The Navy Yard. This minimum two-seat transit trip incurs the inconvenience of a travel time penalty. Providing high quality transit and eliminating the need for transfers would improve travel times for current riders and attract new riders.

### NEED FOR TRANSIT SERVICE TO MAXIMIZE AND MAINTAIN THE NAVY YARD'S GROWTH POTENTIAL

The Broad Street Subway Extension would support greater densities and produce a positive net benefit to property values within a walkable proximity of its stations. The BSLX would leverage, catalyze, and greatly enhance the development potential of the entire Navy Yard, generating investment, employment, and tax returns for the city and state. Without the BSLX, The Navy Yard is at risk of becoming increasingly suburban with large parking areas, lower density development, and limited amenities.

### NEED FOR TRANSIT SERVICE TO ENHANCE AND SUPPORT SUSTAINABILITY PLANS

The adoption of the preferred alignment for the Broad Street Line Extension will assist in meeting the following sustainability goals outlined in adopted plans:

- Improve greenhouse gas and criteria air pollutant emissions performance
  - SEP-TAINABLE and Greenworks Philadelphia
- Increase transit mode share
  - SEP-TAINABLE
- Improve air quality toward attainment of federal standards
  - Greenworks Philadelphia
- Provide walkable access to park and recreation resources for all Philadelphians
  - Greenworks Philadelphia
- Improve transit access to The Navy Yard by increasing the frequency of and extending transit service
  - Lower South District Plan

## 3.3 PROJECT GOALS & OBJECTIVES

The project goals and objectives, summarized in Table 3, complement the P&N and focus on related socio-economic, economic development, environmental, cost efficiency, and transportation issues. They can directly or indirectly correspond to the project justification requirements spelled out for the New Starts funding.

| Category | Goals | Objectives |
|---|---|---|
| Socio-economic | *To ensure a ladder of opportunity by providing access to employment in The Navy Yard.* | Provide transit connections to Center City Philadelphia to increase employment opportunities for low to moderate income individuals in the greater Philadelphia region. |
| | | Provide transit that leads to increases in personal income, total employment, and employment in key employment categories in the Study Area. |
| Economic Development | *To leverage past and future investments in The Navy Yard to increase the economic competitiveness of the City of Philadelphia and the Commonwealth.* | Enable The Navy Yard to reach its fullest growth potential as envisioned in the master plan. |
| | | Promote one-seat travel between Center City and The Navy Yard to connect two major commerce centers with frequent, convenient travel options. |
| | | Continue to promote growth of The Navy Yard to serve as a model center for innovation in work-live-play developments in the Commonwealth. |
| Environmental | *To advance the joint sustainability agenda of the City of Philadelphia and SEPTA.* | Avoid or minimize impacts to sensitive environmental and cultural resources. |
| | | Provide a travel option that will enable passengers to reduce their carbon footprints and reduce the GHG emissions of transportation to and from The Navy Yard. |
| | | Provide a reliable transportation mode that allows for efficient land use and minimizes parking demand. |
| | | Provide a travel option beneficial to the region's air quality. |
| Cost Effectiveness | *To implement a cost-effective and financially feasible heavy rail link to The Navy Yard.* | Minimize the cost per rider for both capital and operating expenses. |
| | | Develop an alternative that will have an operating and maintenance cost that can be funded within regional funding constraints. |
| | | Provide maximum opportunities for partnerships and cost sharing in the public and private sectors. |
| Mobility Improvement | *To increase mobility between The Navy Yard, Center City, and the greater Philadelphia region.* | Provide optimal frequency, capacity and span of service. |
| | | Provide a travel option that reduces trip time for those traveling to and from The Navy Yard. |
| | | Provide a travel option that enhances transit access to The Navy Yard. |
| | | Increase the percentage of people using transit as their preferred mode of transportation to get to and from The Navy Yard. |

**Table 3 – Project Goals and Objectives**

# 4 IDENTIFICATION OF ALTERNATIVES

## 4.1 SCENARIOS IDENTIFICATION PROCESS OVERVIEW

The scenarios identification and evaluation effort involved a three-step process shown in Figure 11. The process began with an initial set of alternatives identified based on input received from the key stakeholders, review of existing and projected study area conditions, previous studies and recommendations, and the scenarios' responsiveness to the project Purpose and Need and goals and objectives. Following a series of meetings with the key stakeholders, several alternatives were selected and refined to be carried forward: three heavy rail scenarios and three enhanced bus scenarios.

To provide a basis for more detailed evaluation and comparison, the initial six alternatives were further developed. Conceptual design plans, capital costs, operating plans, and operating and maintenance (O&M) costs were developed for each alternative for the evaluation. In addition, the metropolitan area's regional planning agency, DVRPC, utilized the regional travel demand model to estimate a set of performance indicators for each alternative, including ridership and vehicular travel forecasts.

Ultimately, the process of identifying potential subway and enhanced bus scenarios into The Navy Yard accounted for many constraints: I-95 and entry/access points to The Navy Yard, preliminary environmental screening, existing buildings and roadways, and design and build construction costs. The defined purpose of the project - to enhance transit access to The Navy Yard, maximize the area's growth potential, and enhance sustainability – was taken under consideration.

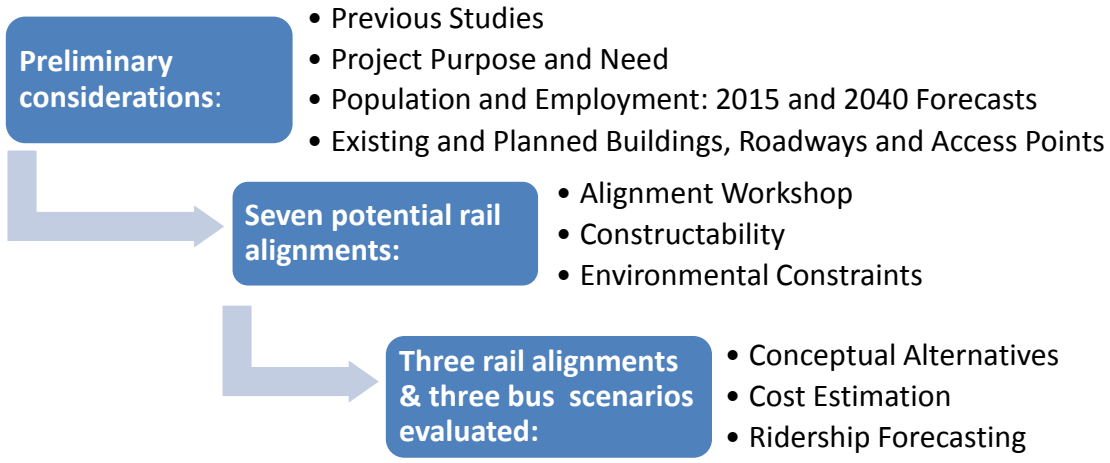



Figure 11 - BSLX Alternatives Identification Process

## 4.2 SCENARIOS DEVELOPMENT

### HEAVY RAIL SCENARIOS

At the Purpose and Need Statement and Potential Alignments Meeting in June 2015, project stakeholders including PennDOT, SEPTA, City of Philadelphia, and PIDC), and The Navy Yard representatives identified potential alignments and stations for the Broad Street Line Extension.

The attendees were divided into two groups, and each group was provided with a map of The Navy Yard, pens, markers, sticky note cards, and a circular measurement device representing a one-quarter mile radius/one-half mile diameter according to the map scale. The maps used for the workshop included The Navy Yard, bounded north from I-95, south to Admiral Peary Boulevard/Delaware River, west to 17th Street, and east to an area just beyond Kitty Hawk Avenue. Intersections contained information on existing employment, target employment, and target residents within a quarter-mile radius of the intersection.

Data on existing employment, target employment, and target residents were obtained by extracting data from shapefiles received from the PIDC that contained an existing number of employees per building and an estimated number of maximum employment and maximum residents per building type for the year 2040 at final build-out.

Workshop participants were allocated adequate time to discuss and select the potential subway path and stations, and indicated their choices on the provided maps by drawing potential routes and stations on the map, as illustrated in Figure 12 and Figure 13. In the end, the participants identified seven potential BSLX service alignments to The Navy Yard in total, with slight variations in routing, the number of stations, and their locations.

The recommendations made by the workshop participants were aggregated based on similarities into one single map and three alignments were selected for further consideration based on their ability to meet broad project objectives:

- Alignment 1, with one stop along Rouse Boulevard near Central Green;
- Alignment 2, with two potential stops, one near the intersection of 13th Street and Intrepid Avenue, and the second stop along Kitty Hawk Avenue east of League Island Boulevard;
- Alignment 3, with one potential stop near Broad Street and Constitution Avenue, and a second stop along Kitty Hawk Avenue east of League Island Boulevard.

A summary of the meeting to identify potential BSLX alignments is included in Appendix A.

By investigating previous studies and working with key project stakeholders, these initial potential BSLX alternatives were evaluated in more detail. The overriding goal of the initial identification was to meet the project Purpose and Need. The other considered factors included:

1. Existing and targeted employment and residential populations within The Navy Yard
2. Transit demand and potential in South Philadelphia's sports complex area
3. Existing and proposed buildings and roadway network in The Navy Yard

Three potential horizontal subway alignment and station location alternatives were identified, as shown in Figure 14. The scenarios were largely chosen based upon project justification data containing:

- Population and employment data at the traffic analysis zone level (TAZ) for current year 2013 and horizon year 2040
- Location and magnitude of affordable housing
- Location and magnitude of transit-dependent populations, and supportive land use policies.

At this level of screening, the evaluation of the alignments was largely qualitative, assessing the degree to which they meet project purpose and need and how they compare to each other. The alignments were selected based on a few attributes:

- Alignment 1, with a single stop within the existing Corporate Center development, could provide the shortest one-seat ride to the already existing high-density employment area.
- Alignment 2, with the first stop near the intersection of 13th Street and Intrepid Avenue, would serve the existing Corporate Center development, while the second stop along Kitty Hawk Avenue east of League Island Boulevard could serve future development in the Mustin Park and Canal District areas.
- Alignment 3, with one stop along Broad Street could provide a one-seat ride to the existing, populated Urban Outfitters campus west of Broad Street, while the second stop along Kitty Hawk Avenue east of League Island Boulevard could serve future development in the Mustin Park and Canal District areas.

For each of the three heavy rail alignments, the geometry and orientation would not preclude a future extension beyond The Navy Yard into New Jersey. The three alternatives are described in more detail below. All alternatives assume a 2040 horizon year.


**Figure 12: Alignments Workshop Group 1 Recommended Alignments**

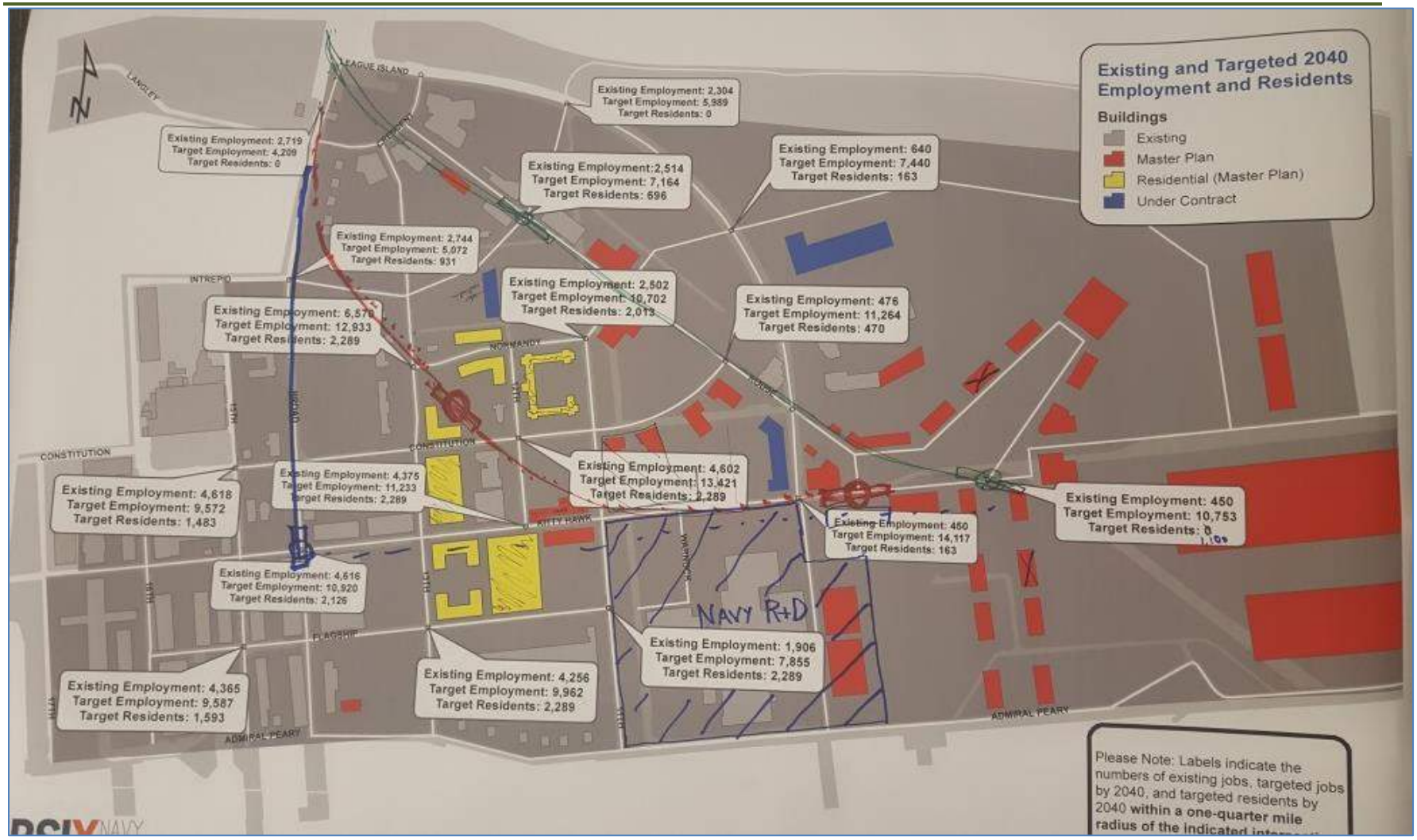



Figure 13: Alignments Workshop Group 2 Recommended Alignments

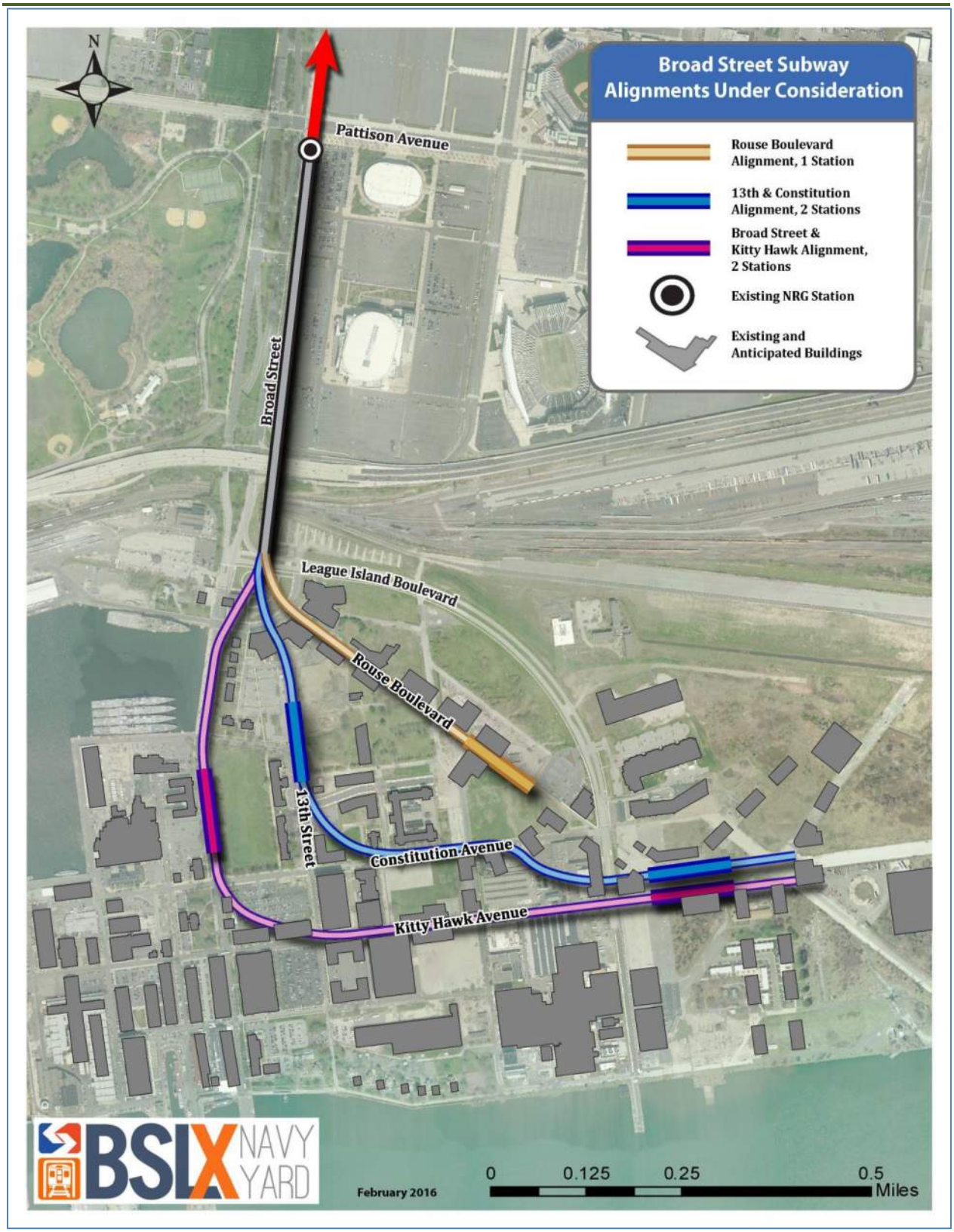



Figure 14 - BSLX Heavy Rail Alternatives

### 2040 NO BUILD ALTERNATIVE

The No Build baseline alternative includes all the existing highway and transit services and facilities, as well as future committed transit improvement projects to the regional transit network, as identified in the DVRPC's adopted Long-Range Transportation Plan.

### 2040 BUILD ALTERNATIVE 1: ROUSE BOULEVARD ALIGNMENT

Alignment 1 begins at NRG Station and follows Broad Street south to its intersection with League Island Boulevard. The route of this alignment then crosses below Crescent Park and turns towards Rouse Boulevard, which it follows southeast until the proposed station along Rouse Boulevard near Central Green. Alternative 1 does not have an intermediate station and includes only one new BSL station. The Rouse Boulevard alignment is the shortest route among the conceptual alignments.

Figure 15 illustrates the potential alignment and station along with a ¼ mile diameter capturing the existing and targeted employment and population.

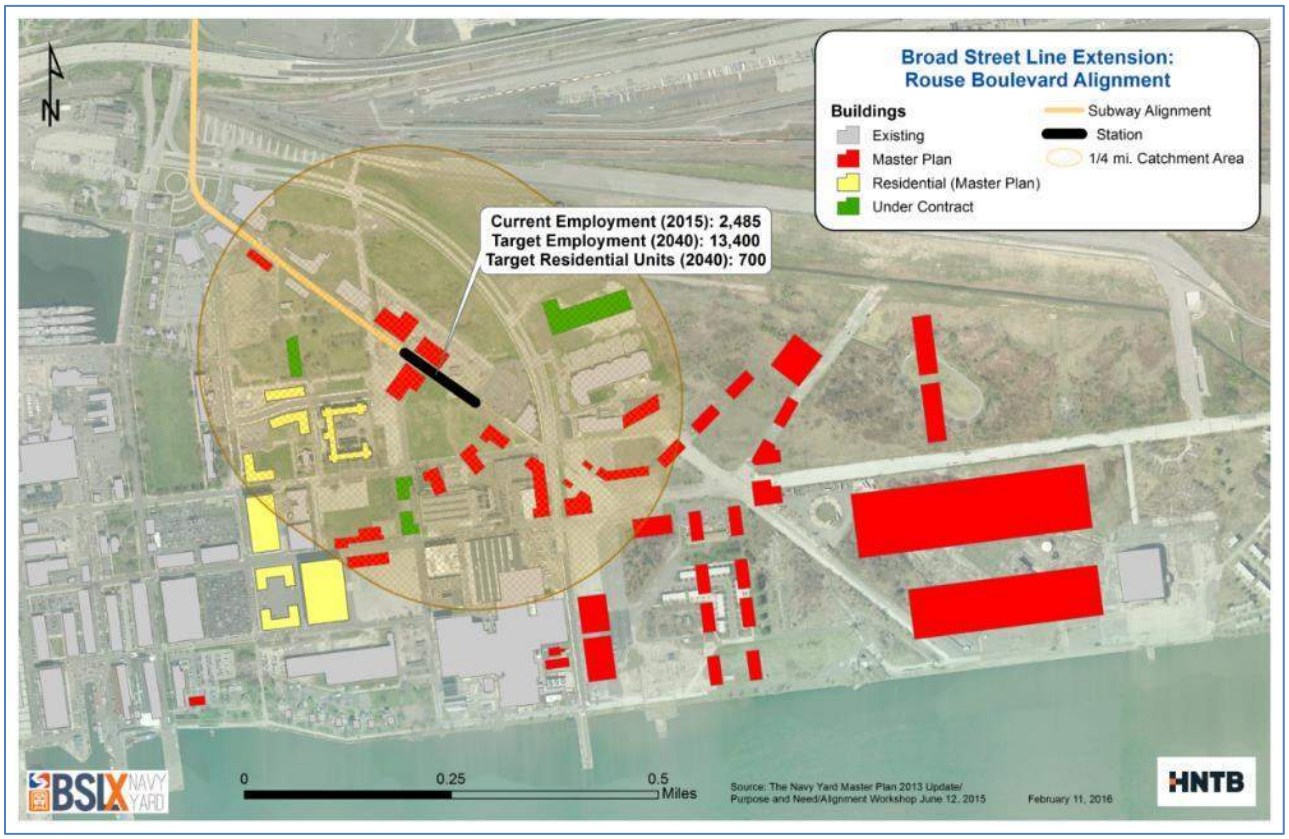



Figure 15 - Rouse Boulevard Alignment & Population Catchment

### 2040 BUILD ALTERNATIVE 2: 13TH STREET AND CONSTITUTION AVENUE ALIGNMENT

Alignment 2 begins at NRG Station and follows Broad Street south into The Navy Yard. However, instead of turning toward Rouse Boulevard, Alignment 2 routes itself towards 13th Street. The route of this alignment turns east underneath Constitution Avenue and then Kitty Hawk Avenue. The first station along this alignment is proposed near the intersection of 13th Street and Intrepid Avenue. The terminus station for this alignment is proposed on Kitty Hawk Avenue east of its intersection with League Island Boulevard.

Figure 16 illustrates the potential alignment and station along with a ¼ mile diameter capturing the existing and targeted employment and population.

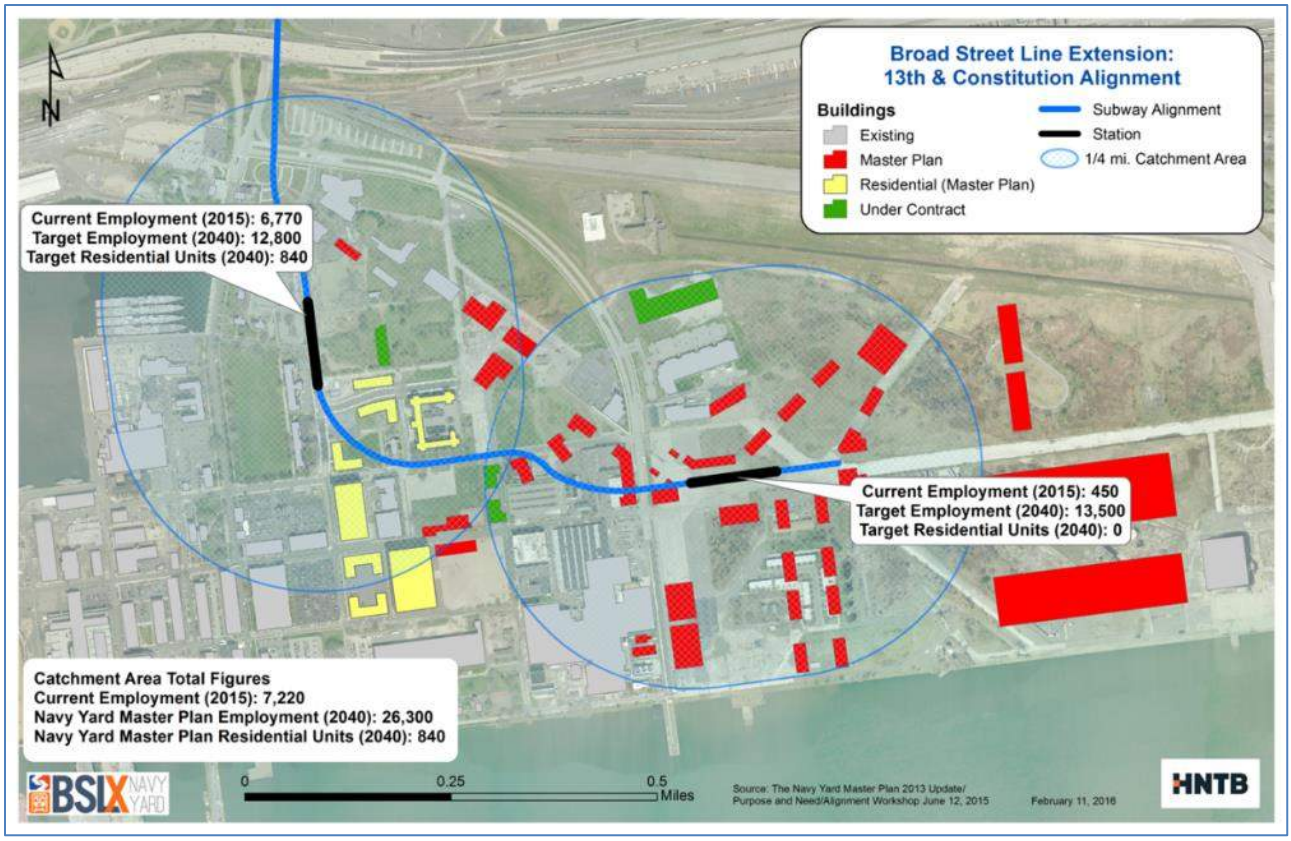



Figure 16 - 13th Street and Constitution Avenue Alignment & Population Catchment

### 2040 BUILD ALTERNATIVE 3: BROAD STREET AND KITTY HAWK AVENUE ALIGNMENT

Alignment 3 begins at NRG Station and continues down Broad Street until it reaches Kitty Hawk Avenue. The first proposed station along this route is located along Broad Street, adjacent to the Marine Parade Grounds between Intrepid Avenue and Constitution Avenue. The route of this alignment turns east on Kitty Hawk Avenue and follows underneath this street until its proposed terminus station east of League Island Boulevard.

Figure 17 illustrates the potential alignment and station along with the ¼ mile diameters capturing the existing and targeted employment and population.

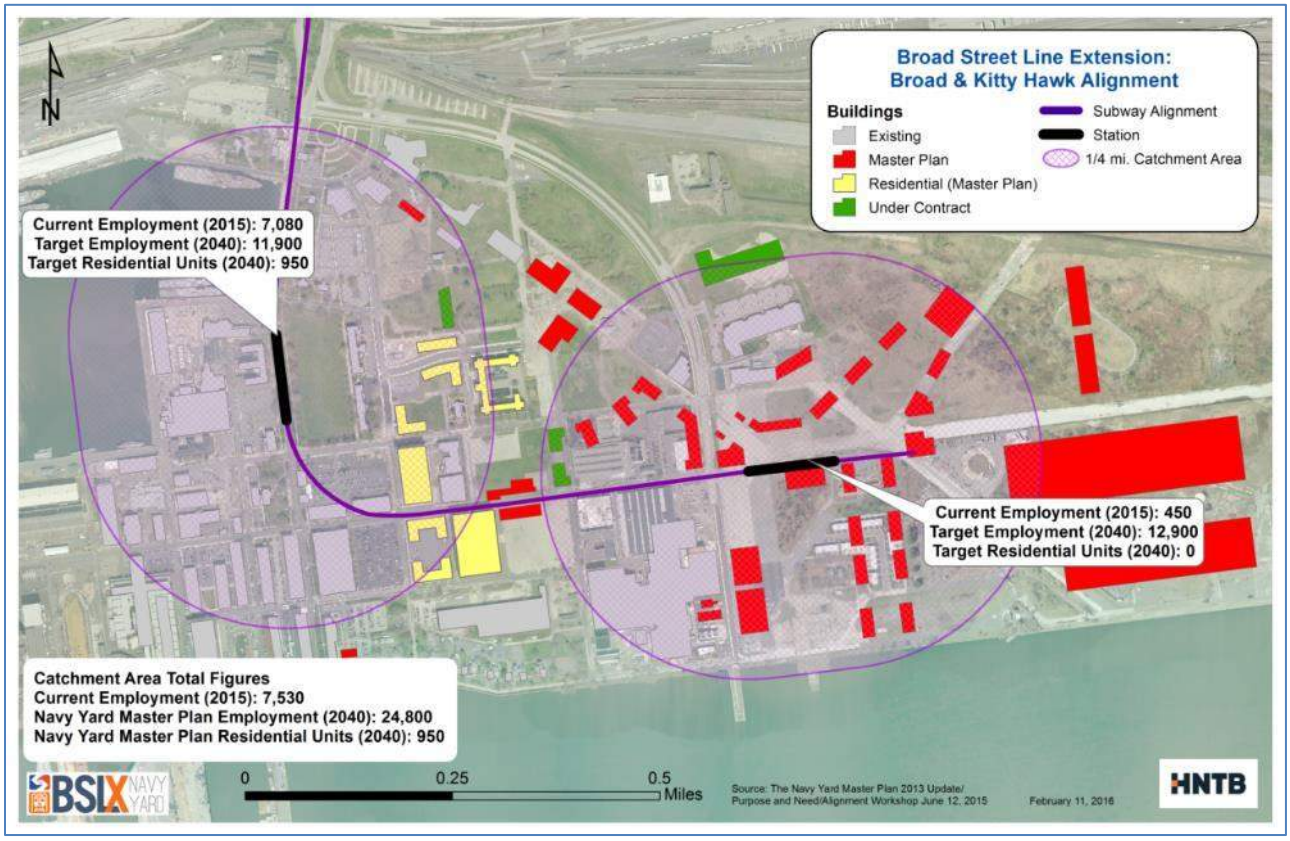



**Figure 17 - Broad Street and Kitty Hawk Avenue Alignment & Population Catchment**

Conceptual plans, profiles and sections were developed for the three heavy rail alignments under consideration. The conceptual design is summarized in Appendix B.

### HORIZON YEAR BUS FEEDER SERVICE

The heavy rail scenarios' new station(s) would be served by appropriate bus feeder route(s), similar to the current services at existing NRG Station. The future year rail scenarios would result in modifications to both shuttles' operating plans, with significant increase in service frequency and service hours, and routing adjusted to match a slightly modified street network, as proposed in The Navy Yard's Master Plan.

The Navy Yard Loop would be split into 'East' and 'West' Loop with modified routing and increased service frequency tailored to provide timed transfer to/from the new extended BSL station(s) in The Navy Yard. The East and West Loop shuttles would operate as follows:

- East Loop:

- Meet every inbound Navy Yard bound BSL train in the morning, runs counterclockwise; and, meet every outbound train in the afternoon, runs clockwise
- 130 daily runs
- 10 min end-to-end runtime
- Headways: 7 to 25 mins

- West Loop:
  - Meets every other inbound Navy Yard bound BSL train in in the morning, runs clockwise; and, every other outbound train in the afternoon, runs counterclockwise
  - 65 daily runs
  - 13 min end-to-end runtime
  - Headways: 14 to 40 mins

The existing Express shuttle service would be discontinued in all the three BSLX scenarios.

Using the above assumptions, sketch-level bus feeder network timetables/schedules were developed with assistance from SEPTA's Service Planning staff. The bus feeder network developed for the three subway alternatives is shown in Figures 18 through 20.

## ENHANCED BUS SCENARIOS

During a meeting conducted in October 2015, PennDOT requested development of bus-only alternatives to permit direct comparison of rail versus bus modes. The Navy Yard is currently served by several bus routes, with the nearest heavy rail service available at NRG Station. The bus scenarios' identification process involved assessment of the current level of service for the bus routes serving the area. Service attributes such as span, frequency, and vehicle fleet were considered to understand the existing transit demand and supply. Land use, population, employment projections, and trip patterns were analyzed to determine potential routing for the studied bus alternatives.

Multiple routes and alignment alternatives were evaluated. Through a series of meetings and multiple iterations with SEPTA's Service Planning staff conducted in the spring and summer of 2016, the study team gained concurrence on the three bus-only alternatives that would provide service comparable to the heavy rail scenarios with incremental increase in O&M costs only and minimal capital investment.

The resulting Alternative 4 would include the new 'East' and 'West' Loop with modified routing and increased service frequency tailored to provide timed transfer to/from NRG Station. Alternative 5 would include the Express shuttle in addition to Loop service, while also increasing its service span and frequency. A third bus alternative that would provide service to The Navy Yard by extending one of the existing SEPTA's bus routes was sought to be evaluated. SEPTA Route 45 emerged as the most suitable contender after considering:

- Route 4 and 47: both were initially considered but eliminated during the discussions. The former would be too duplicative of the existing Broad Street Line subway service, while the latter was

considered to operate too far east through south Philadelphia in comparison to other candidate routes.

- Route 17: deemed a fitting candidate since it already serves The Navy Yard on the weekends, but its current high frequency of weekday service, with 4-minute headways on local surface streets could impact the route's reliability and on-time performance.
- Route 45: could be extended to The Navy Yard by following the existing Route 17 Navy Yard weekend alignment south of Packer Avenue. The analysis showed that Route 45 would capture a large percentage of employment trips destined for The Navy Yard if its alignment outside of The Navy Yard is largely unchanged and its every run extends to The Navy Yard.

The three bus alternatives are described in more detail below. All alternatives assumed a 2040 horizon year.

### 2040 BUILD ALTERNATIVE 4: LOOP

Alternative 4 enhances the existing Loop by increasing service frequency and service hours. Supporting bus service characteristics are identical to those defined under the heavy rail scenarios except for minor routing adjustments to the existing NRG Station rather than the potential new subway station(s). It discontinues the existing Express shuttle service. This scenario assumes no change in heavy rail service, with BSL subway terminating at NRG Station.

### 2040 BUILD ALTERNATIVE 5: EXPRESS & LOOP

Alternative 5 also enhances the existing Loop by increasing service frequency and service hours. However, it also includes an enhanced Express shuttle connecting Center City to/from The Navy Yard via I-95. This scenario assumes no change in heavy rail service, with BSL subway terminating at NRG Station.

### 2040 BUILD ALTERNATIVE 6: ROUTE 45 & LOOP

Alternative 6 extends every existing run of SEPTA Route 45 bus to The Navy Yard and modifies it to follow the existing SEPTA Route 17 weekend service alignment to The Navy Yard. Akin to Alternative 4, the existing Express shuttle service would be discontinued. The Loop shuttle would be enhanced by increasing its service frequency and service hours, but only Loop West would be included in this scenario. Alternative 6 assumes no change in heavy rail service, with BSL subway terminating at NRG Station.

Using the above assumptions, sketch-level bus alternatives timetables/schedules were developed with assistance from SEPTA's Service Planning staff. The bus scenarios are shown in Figures 21 through 23.

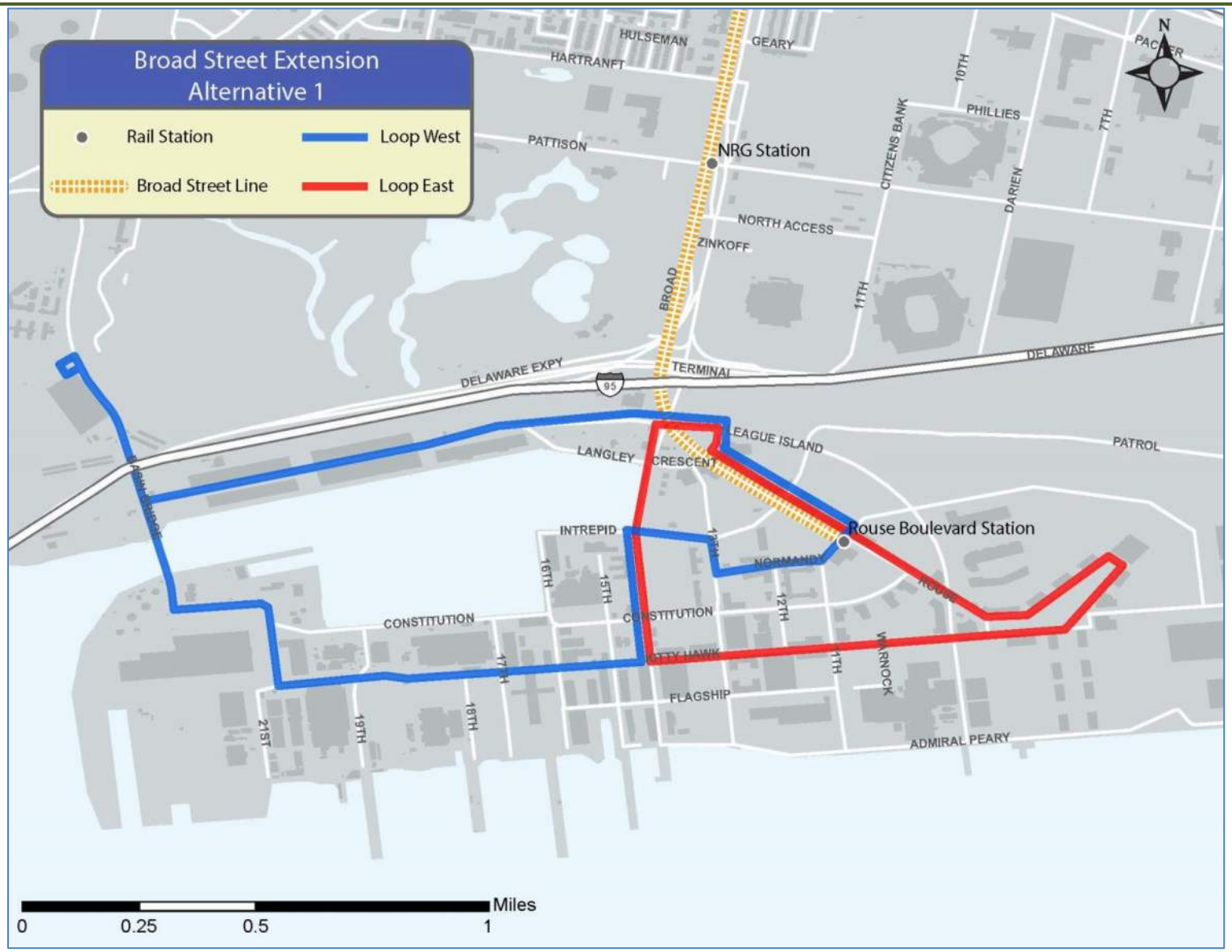



Figure 18 - Alternative 1 Bus Feeder Network

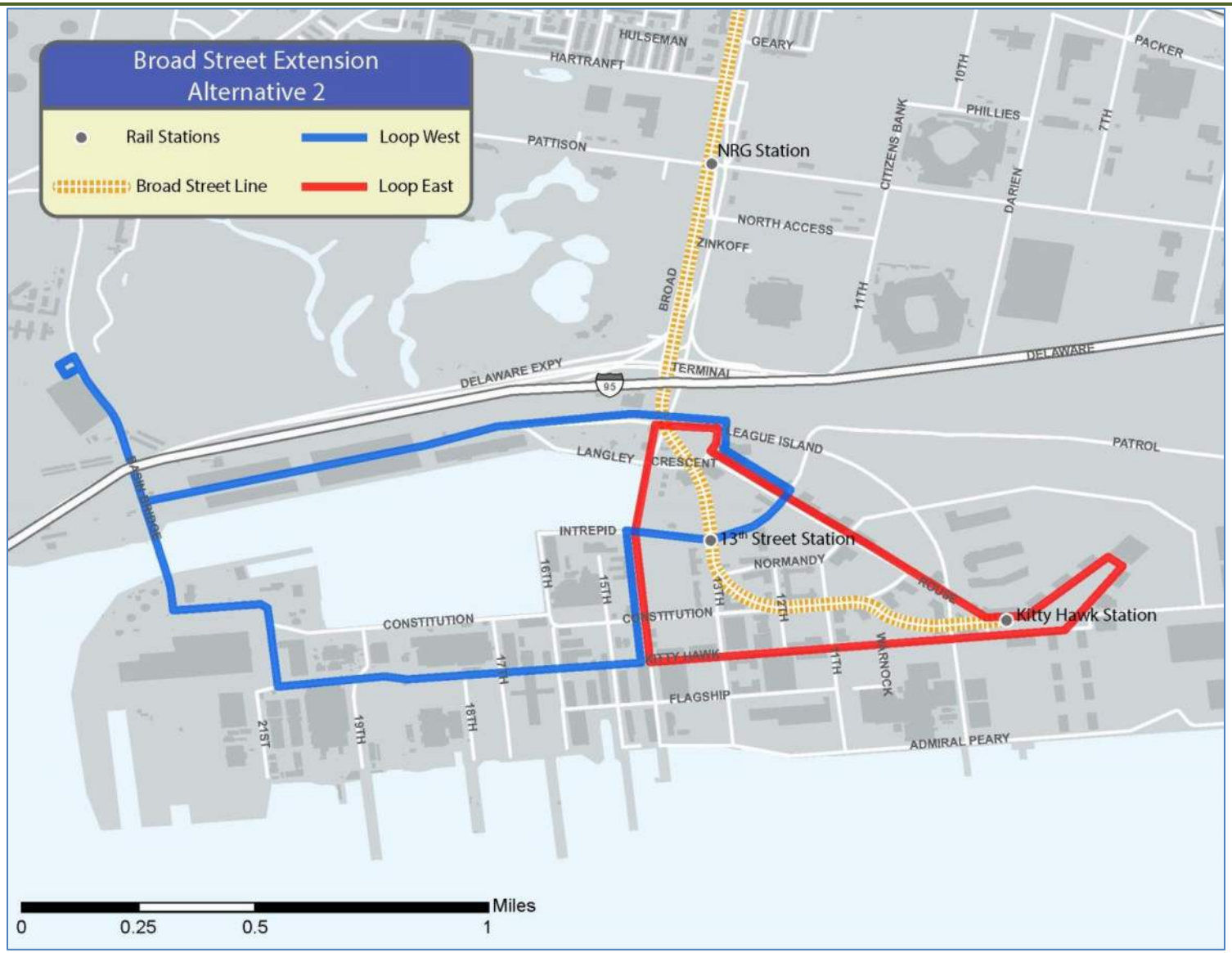



Figure 19 - Alternative 2 Bus Feeder Network

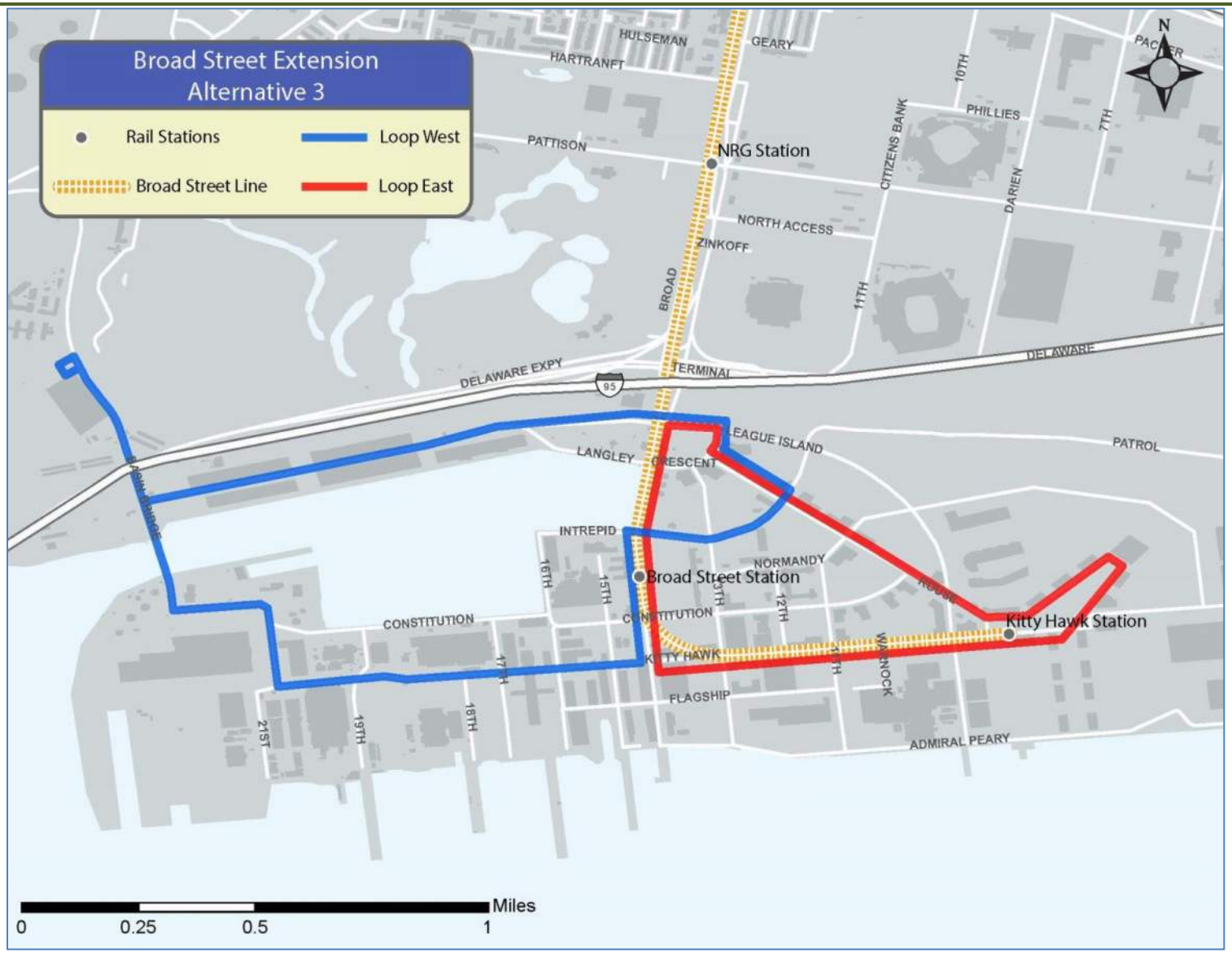



Figure 20 - Alternative 3 Bus Feeder Network

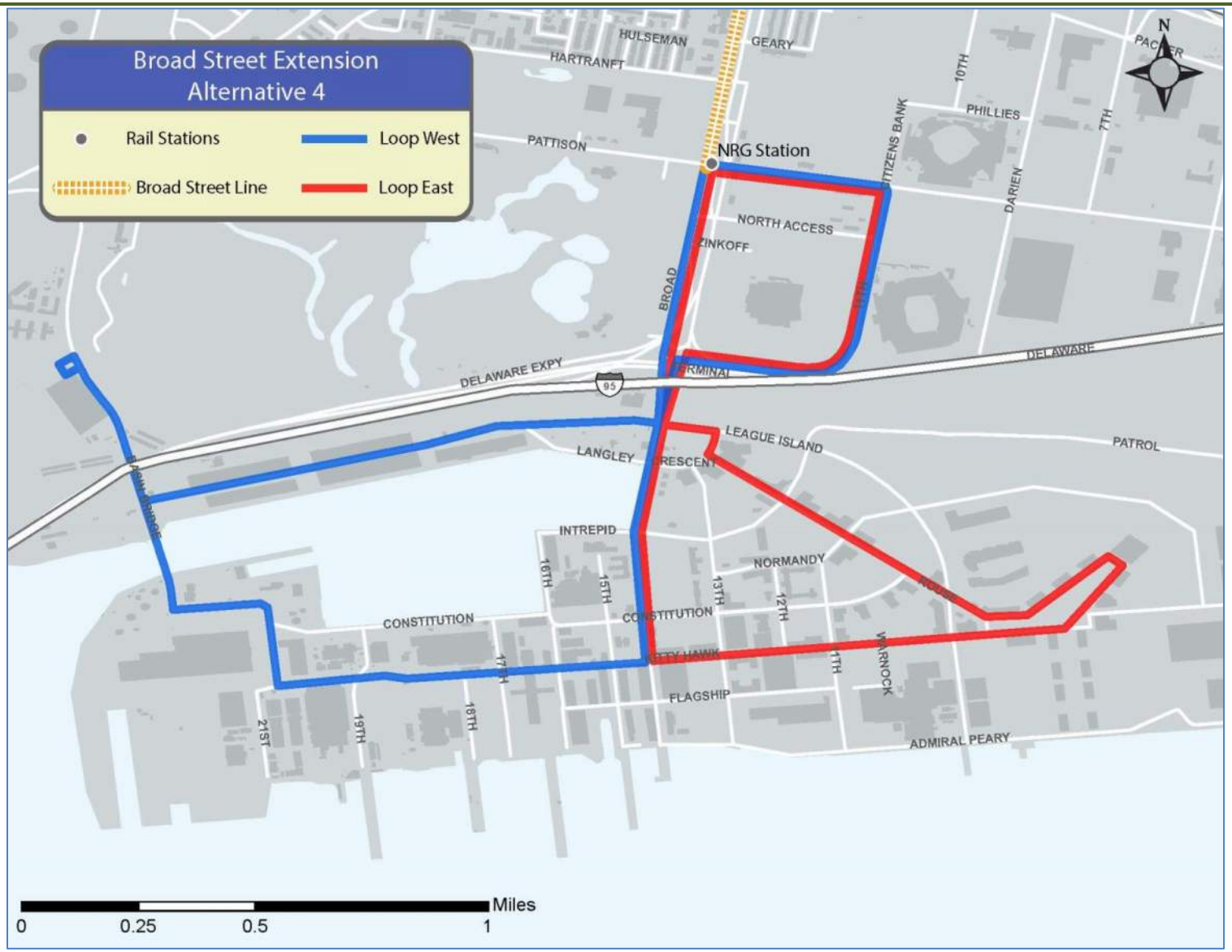



Figure 21 - Alternative 4 – Loop

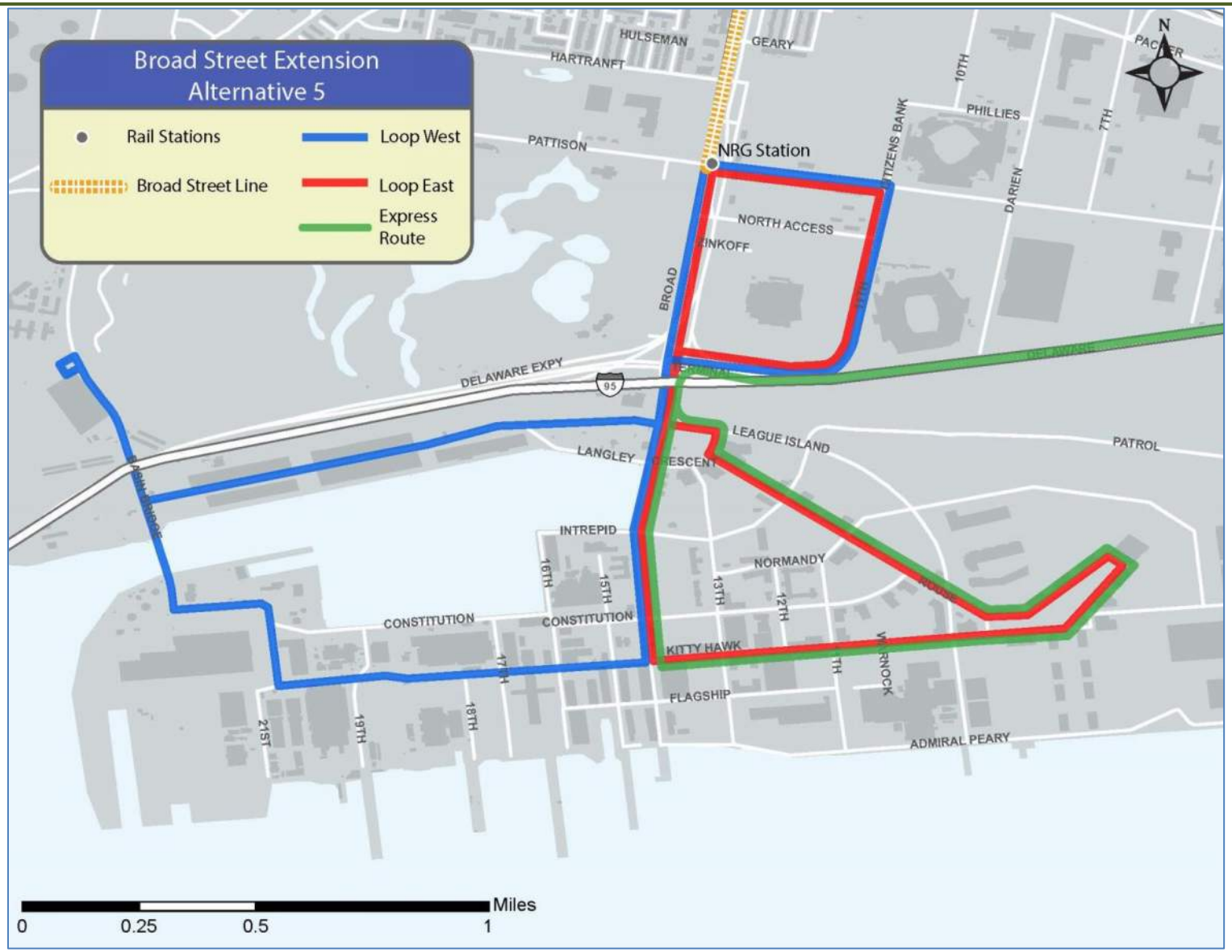



Figure 22 - Alternative 5 – Loop and Express

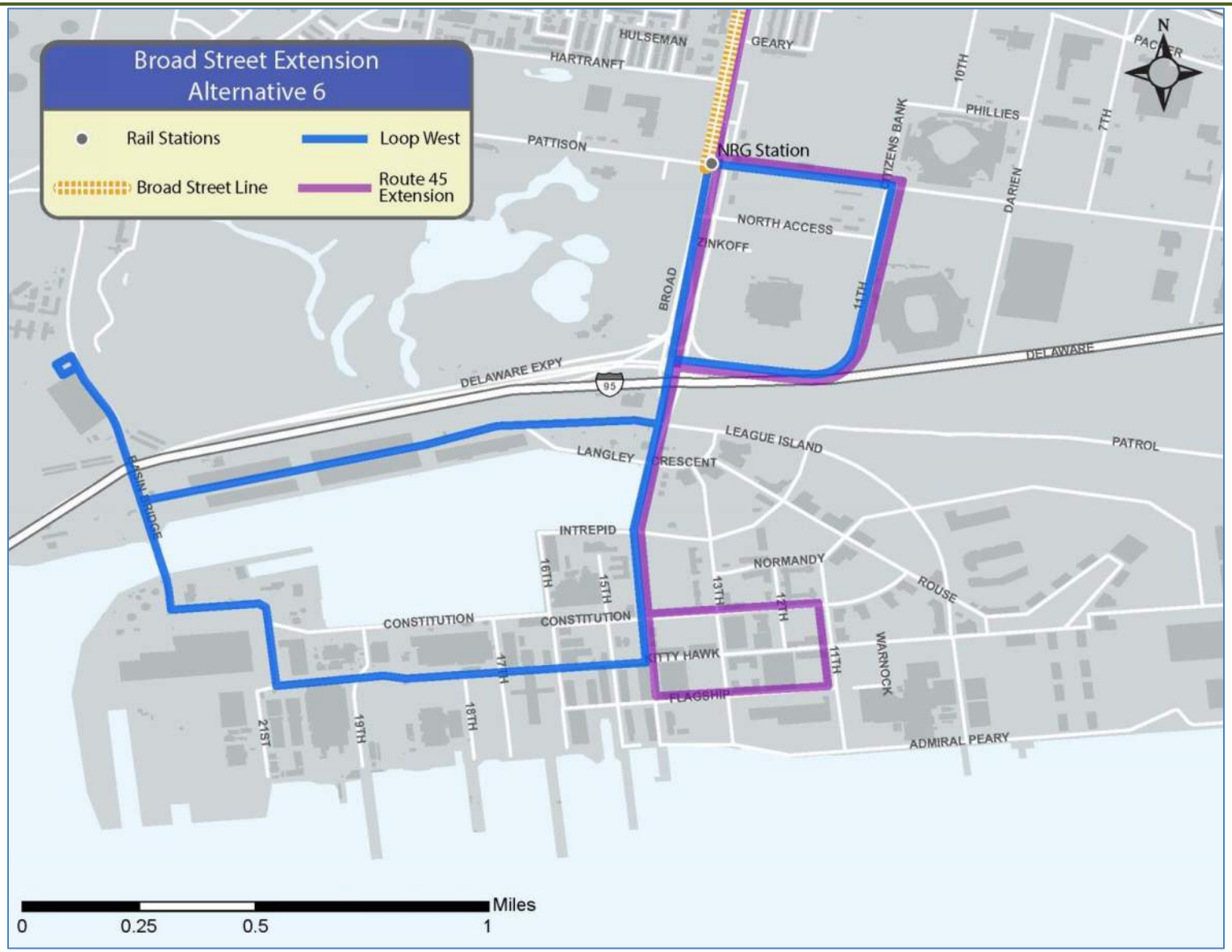



Figure 23 - Alternative 6 - Loop and Route 45

# 5 CAPITAL COST ESTIMATES

## 5.1 BASIS OF ESTIMATES

The FTA Capital Cost Database (CCD) was utilized to generate the Order of Magnitude estimates for each alternative. The FTA CCD contains "as-built" costs for a sample of light and heavy rail projects, with project costs and unit quantities recorded at the Standard Cost Categories (SCC) level of detail.

The costs are in 2018 dollars, adjusted locally to Philadelphia and to size and scope of each alternative and option. In addition, the Cut and Cover Guideway and Station unit costs were adjusted manually to reflect project specific complexities for shoring of excavation (SOE) and ground improvements. All costs are based on the total linear miles of guideway, including necessary tail tracks.

Soft costs were added at 47% to account for Professional Services. Finally, a range of values was generated based on FTA guidelines of Probable Accuracy.

## 5.2 CAPITAL COST ESTIMATES

Table 4 summarizes the anticipated capital project costs based on FTA Guidelines (with contingency included in the cost estimate). Details are included in Appendix B. Note: capital costs for the evaluated bus-only scenarios are assumed to be minimal and thus omitted from the table and analysis.

| Heavy Rail Alignment | Guideway Length | # of Stations | Cost Category | Cost Estimate (2018 $M) |
|---|---|---|---|---|
| **1. Rouse Boulevard** | 4,7800 LF | 1 | Construction (SCC 10-50) | $633 |
| | | | Soft (SCC 60-100) | $351 |
| | | | **Total** | **$984** |
| **2. 13th Street & Constitution Ave** | 8,100 LF | 2 | Construction (SCC 10-50) | $1,104 |
| | | | Soft (SCC 60-100) | $604 |
| | | | **Total** | **$1,708** |
| **3. Broad Street & Kitty Hawk Ave** | 9,300 LF | 2 | Construction (SCC 10-50) | $1,172 |
| | | | Soft (SCC 60-100) | $648 |
| | | | Total | **$1,820** |

**Table 4 – BSLX Heavy Rail Alternatives Capital Cost Estimates**

Notes:

- FTA Capital Cost database utilized for point estimate values
- Costs are in 2018 dollars, adjusted locally to Philadelphia, Pennsylvania
- Soft Costs have not been adjusted
- Estimate values exclude finance charges (SCC-100)
- Estimated contingencies allocated to SCC code based on level of information and risk.
- Unit Cost for Cut & Cover Guideway and Stations adjusted to include project specific complexities for SOE and Ground Improvements

# 6 OPERATING AND MAINTENANCE COST ESTIMATES

## 6.1 O&M COST METHODOLOGY

Unlike the capital costs that represent the cost of designing and building transit projects and replacing assets, the operating and maintenance (O&M) costs include the on-going costs that would be incurred to operate, maintain, and manage each of the potential Broad Street Subway Extension (BSLX) alternatives, including its bus feeder network (if applicable), and/or an enhanced bus service with similar service characteristics to subway.

The O&M cost estimating typically involve:

1. Developing methodology for estimating O&M costs
2. Selecting cost model(s) that consider each transit mode, zone, and service provider
3. Calibrating the model(s) for current year operations
4. Generating operating plan(s) for each scenario
5. Calculating annual O&M costs for each study alternative

The scenarios evaluated for the O&M implications included:

- No Build alternative
- Heavy rail alternatives: 1, 2, and 3
- Bus alternatives: 4, 5, and 6.

All alternatives were defined for the horizon year 2040. Transit operations affected by the project alternatives include:

- SEPTA's Broad Street Line (heavy rail) – multiple potential extension alignments from the existing NRG Station to The Navy Yard are considered.
- SEPTA's Route 45 (bus) – extension of service to The Navy Yard via NRG Station is considered.
- PIDC's shuttle services – the existing Loop and Express employee shuttles (fare-free) are currently operated by Krapf's Coaches through a contract with PIDC. Routing for both shuttles is proposed to be modified, with a significant increase in service frequency and service hours. The shuttles' operator in the horizon year is undetermined for this analysis.

### FTA O&M COST MODEL GUIDANCE

Although the BSLX Phase 2 Feasibility Study examines transit options at a conceptual level, if one of the three subway extension scenarios would be advanced to a design and construction phase, a complete Federal Transit Administration (FTA) New Starts Financial Analysis would need to be completed to secure federal funding. Estimates of O&M costs are an important part of the FTA New Starts planning.

According to the FTA guidance (included in FTA's 2011 *Procedures and Technical Methods for Transit Project Planning Manual*), an O&M cost model should reflect the up-to-date operating characteristics of the service provider, with line-item detail expenses for different modes, including wages, salaries,

materials and supplies, and fringe benefits. The O&M costs for the BSLX study are estimated using SEPTA's **Three-Variable Fully Allocated Cost Model** calibrated to SEPTA's 2018 fiscal year (FY) 2018 Adopted Budget and used in the Route Operating Ratio Reports (ROR) and the latest Annual Service Plan (ASP). SEPTA's model and its key cost driving variables are described in more detail below.

## SEPTA'S THREE-VARIABLE COST MODEL

SEPTA's **Three-Variable Fully Allocated Cost Model** is the FTA-recommended model based on a resource build-up approach with costs computed by estimating quantities of unit costs required to provide a given level of service. SEPTA's model is used by the agency to estimate annual O&M costs to operate, maintain and administer its separate operating modes within a given division: city transit - heavy rail, streetcar, trackless trolley, and local/express bus; suburban transit - local/express bus, and streetcar; and regional rail.

The **Three-Variable Fully Allocated Cost Model** assumes that each O&M expense incurred by SEPTA is driven by the three key supply variables: **vehicle-hours**, **vehicle-miles**, and the number of **peak vehicles**, with their major cost components as follows:

1. **Per vehicle hour cost**. When calculated annually, the hours that vehicles travel while in service over the entire fiscal year. Vehicle hours include layover and schedule recovery but exclude deadhead and time needed for operator training and maintenance testing.
   Per vehicle hour cost drives operator costs and includes:
   a. Operator wages
   b. Payroll taxes and benefits

2. **Per mile cost**. The miles that vehicles travel while in service over the entire fiscal year. Vehicle miles include layover and schedule recovery but exclude deadhead and time needed for operator training and maintenance testing. Per mile cost drives vehicle maintenance and claims costs and includes:
   a. Fuel/traction power
   b. Vehicle maintenance
      i. Tires
      ii. Parts and labor

3. **Peak vehicle cost**. The maximum number of transit service vehicles - buses or rail cars - in simultaneous operation on an average weekday. This number is updated annually. Peak vehicle cost drives facilities maintenance and some vehicle maintenance costs and includes:
   a. Infrastructure
      i. Equipment and ROW maintenance
      ii. Power/Utilities
   b. Overhead expenses

Multiplying and combining the actual O&M costs with the quantities of relevant supply variables – hours, miles, and vehicles - establishes the fully allocated unit costs. SEPTA utilizes the fully allocated operator cost per vehicle hour, maintenance cost per vehicle mile, and overhead costs associated with peak vehicles in the Route Operating Ratio Reports (ROR) and its Annual Service Plans (ASPs). The incremental peak vehicle cost is used to estimate O&M costs for network expansion projects such as the potential BSL extension.

## BASIS OF O&M ESTIMATES

The selection of the key model inputs drives the operating data collection needs. Conceptual O&M costs for the six BSLX project scenarios use the existing system characteristics and operating statistics (peak vehicles and operating and maintenance vehicle costs by hour and mile) to determine the cost of each scenario. The project cost matrix (Table 5) also includes one revenue variable – average passenger fare – that decreases the overall O&M costs and is a function of the number of fare-paying SEPTA riders (derived from the ridership forecasts).

| Key Supply Variable | Subway Extension | Enhanced Bus | |
|---|---|---|---|
| | | SEPTA – Route 45 | PIDC Shuttles: Loop & Express* |
| Operating Vehicle Hours | X | X | X |
| Operating Vehicle Miles | X | X | X |
| Peak Vehicles | X | X | X |
| Average Passenger Fare | X | X | |

**Table 5 – BSLX Build Scenarios O&M Cost Matrix**

* 2040 Build shuttles' operator to be determined

The following is a summary of each unit's incremental cost basis over the No Build alternative derived from the SEPTA's Three-Variable Fully Allocated Cost Model, applied to scenario, mode, and route / transit service by type (Table 6):

- The incremental costs for Broad Street Subway extension are estimated as: $508,000 per peak period train annually, $111.95 per vehicle hour, $14.65 per vehicle mile, minus average revenue of $1.09 per fare-based passenger trip.
- The incremental costs for SEPTA-operated bus services (Route 45 for this project) are estimated as: $47,000 per peak period vehicle annually, $63.99 per vehicle hour, $3.40 per vehicle mile, minus average revenue of $1.09 per fare-based passenger trip.
- The incremental costs for undetermined shuttle operator bus services are estimated as: $47,000 per peak period vehicle annually, $63.99 per vehicle hour, and $3.40 per vehicle mile. The Loop and Express shuttle services are assumed to continue operating fare-free in the foreseeable future.

All unit costs are estimated in current year 2018 dollars and do not account for future year inflation.

| Scenario | Mode | Average Passenger Fare | Op. Cost per Veh-hour | Maintenance & Op. Cost per Veh-mile | Overhead - per Peak Vehicle | |
|---|---|---|---|---|---|---|
| | | | | | Fully Allocated | Incremental |
| **Alt. 1** | BSLX | $1.09 | $22.39 | $2.93 | $687,100 | **$101,600** |
| | Shuttle Bus | N/A | $63.99 | $3.40 | $197,200 | **$47,000** |
| **Alt. 2** | BSLX | $1.09 | $22.39 | $2.93 | $687,100 | **$101,600** |
| | Shuttle Bus | N/A | $63.99 | $3.40 | $197,200 | **$47,000** |
| **Alt. 3** | BSLX | $1.09 | $22.39 | $2.93 | $687,100 | **$101,600** |
| | Shuttle Bus | N/A | $63.99 | $3.40 | $197,200 | **$47,000** |
| **Alt. 4** | Shuttle Bus | N/A | $63.99 | $3.40 | $197,200 | **$47,000** |
| **Alt. 5** | Shuttle Bus | N/A | $63.99 | $3.40 | $197,200 | **$47,000** |
| **Alt. 6** | SEPTA Bus | $1.09 | $63.99 | $3.40 | $197,200 | **$47,000** |
| | Shuttle Bus | N/A | $63.99 | $3.40 | $197,200 | **$47,000** |

**Table 6 – BSLX Build Scenarios O&M Unit Costs (2018 $s)**

Note: SEPTA's model Broad Street Line calculates the average BSL passenger fare per train car, as shown.

## 6.2 OPERATING ASSUMPTIONS

Conceptual operating and maintenance costs for the BSLX scenarios were calculated based on reported transit service characteristics and developed operating plans.

### SERVICE CHARACTERISTICS

Heavy rail characteristics used in the O&M cost models were determined from ridership outputs from the regional Travel Improvement Model (TIM), engineering drawings and surveys, General Transit Feed Specification files (GTFS) for SEPTA, and SEPTA's Operating Facts and Route Statistics. Bus service characteristics are also a function of ridership outputs from the regional TIM, GTFS files for SEPTA, SEPTA's Operating Facts and Route Statistics, and PIDC operating data.

Peak hour load analysis was cursory, with the assumption that a projected ridership could largely be accommodated by the No Build vehicle fleet, where fleet increase is a function of increased travel time and distance. Travel times considered the design speed for each alignment with maximum speed restrictions, acceleration and braking time, geometry, distance between stops, dwell times at stops, and average delay expected at intersections (traffic conditions applicable to bus only).

The following vehicle information was used in the calculation, based on the Broad Street Subway B-IV Car:

- Acceleration rate: 1.5 mphps
- Deceleration rate: 2.2 mphps
- Line MAS: 50 mph

- Consist length: 8 cars; 542.7 feet

Operational assumptions were as follows:

- Station dwell time: 30 seconds
- Minimum time at constant speed: 5 seconds

It is assumed that there would be no short-turns for the extended subway service. Table 7 shows the conceptual travel times and station dwell time assumptions for the studied rail alternatives.

| Alignment | | NRG Station to Intermediate Station* | | | Intermediate Station * to Terminal Station | | | Total NRG Station to Terminal Station** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Direction | Speed | Distance | Time | Speed | Distance | Time | Speed | Distance | Time |
| | [NB/SB] | [mph] | [fat] | [sec] | [mph] | [ft] | [sec] | [mph] | [ft] | [sec] |
| **1. Rouse Blvd** | NB | - | - | **-** | - | - | **-** | 27.1 | 4811 | **121.0** |
| **1. Rouse Blvd** | SB | - | - | **-** | - | - | **-** | 29.1 | 4887 | **114.5** |
| **2. 13th St** | NB | 28.0 | 3982 | **97.0** | 24.0 | 4155 | **118.2** | 22.6 | 8137 | **245.2** |
| **2. 13th St** | SB | 27.0 | 3977 | **100.5** | 25.5 | 4214 | **112.6** | 23.0 | 8191 | **243.1** |
| **3. Broad St** | NB | 29.5 | 4455 | **102.9** | 29.5 | 4778 | **110.3** | 25.9 | 9233 | **243.2** |
| **3. Broad St** | SB | 28.7 | 4454 | **106.0** | 31.7 | 4842 | **104.2** | 26.4 | 9296 | **240.2** |

**Table 7 – BSLX Conceptual Travel Times**

Notes:

* Intermediate Station is 13th Street for Alternative 2 and Broad Street for Alternative 3. Alternative 1 does not have an intermediate station.
** Total for Alternatives 2 and 3 includes assumed 30 second dwell time at intermediate station.

## OPERATING PLANS

In addition to serving as inputs into the O&M cost analysis, the initial draft operating plans for the three potential subway extension alternatives and the three enhanced bus scenarios were developed to (1) identify load capacity; (2) vehicle fleet requirements; and (3) modeling of ridership forecasts. The operating plans specified the number of stations and station locations (or stops for bus service); planned headways and service frequency; travel times between stations; and station dwell times. The turnaround time at the end and beginning of the line extension was excluded.

The assumptions for the initial draft operating plans were coded into the DVRPC's TIM, a package of software programs that simulate regional travel behavior for all transportation modes. Following the development of preliminary ridership forecasts for the No Build and all Build horizon year alternatives, the initial operating plans were refined to reflect service levels necessary to accommodate the projected ridership and to better reflect expected vehicular traffic and level of service within The Navy Yard and regionwide. This approach is responsive to FTA guidance to design future year service options to meet the forecasted transit demand within a given study area.

The operating plans for the three rail-based alternatives would:

- Extend the existing BSL service at NRG station southbound to The Navy Yard.
  The BSL service beyond NRG would operate on headways equal to that of the existing service operating between the Fern Rock Transportation Center in North Philadelphia and the NRG Station.
- The existing Loop bus shuttle service would be modified to be in sync with inbound and outbound BSL schedules.
- The existing PIDC Express shuttle bus service from Philadelphia City Center to Navy Yard would be discontinued.

The bus-only scenarios would revamp and prompt changes to the existing bus service network serving The Navy Yard with increased frequencies and modified routing for the Loop and Express shuttles, and Alternative 6 extending SEPTA's Route 45 to The Navy Yard. In all considered bus scenarios, the BSL would continue to terminate at the existing NRG station. The operating plan assumptions are summarized in Table 8. The operating schedules / timetables summaries are included in Appendices C and D.

| Scenario | Rail | Bus | |
|---|---|---|---|
| | | Loop | Express |
| **BASE: Existing transit system** | No change - BSL subway terminates at NRG Station | *Loop* and *Express* shuttles (PIDC-operated). 2013 schedules. | |
| | | • 38 daily runs<br>• operates 5:38AM-7:14PM<br>• 18 mins runtime<br>• 22 mins headways | • 36 daily runs<br>• operates 6:18AM-7:33PM, mid-day break<br>• 33 mins AM runtime, 43 mins PM<br>• headways: 5 to 35 mins |
| **2040 NO BUILD: Existing transit system w/ funded elements** | No changes to BSL route or schedule | *Loop* and *Express* shuttles (PIDC-operated).<br>End of 2016 schedules, modified for 2040 traffic conditions. | |
| | | • 60 daily runs<br>• operates 5:38AM-7:14PM<br>• 22 mins runtime<br>• 13.5 mins headways<br>• clockwise & counterclockwise service | • 48 daily runs<br>• operates 6:18AM-7:30PM, mid-day break<br>• 42 mins runtime AM, 55 mins runtime PM<br>• headways: 7 to 35 mins |
| **ALT 1: RAIL Rouse / Central Green** | Extends BSL to Navy Yard;<br>1 new station on Rouse Blvd. | *Loop* and *Express* shuttles (operator TBD) | |
| | | *East Loop:* | N/A (No Express) |
| | | • 130 daily runs<br>• 10 min end-to-end runtime<br>• headways: 7 to 25 mins<br>• meets every inbound Rouse Blvd BSL train AM, runs counterclockwise; and, every outbound train PM, runs clockwise | |
| | | *West Loop* | |
| | | • 65 daily runs<br>• 13 min end-to-end runtime<br>• headways: 14 to 40 mins | |

| Scenario | Rail | Bus | |
|---|---|---|---|
| | | Loop | Express |
| | | • meets every other inbound Rouse Blvd BSL train in AM, runs clockwise; and, every other outbound train PM, runs counterclockwise | |
| **ALT 2: RAIL 13th & Constitution** | Extends BSL to Navy Yard;<br>2 new stations: 13th St. & Kitty Hawk Ave. | Similar to Alt 1. Variations in operating plan due to trips originating/terminating at the new BSL 13th Street Station. | N/A (No Express) |
| **ALT 3: RAIL Broad & Kitty Hawk** | Extends BSL to Navy Yard;<br>2 new stations: Broad St. & Kitty Hawk Ave | Similar to Alt 1. Variations in operating plan due to trips originating/terminating at the new BSL Broad St. / Constitution Station. | N/A (No Express) |
| **ALT 4: BUS Loop** | No change - BSL subway terminates at NRG Station | *East Loop:*<br>• ~130 daily runs<br>• 18 mins runtime<br>• meets every inbound NRG train AM, runs counterclockwise; and, every outbound train PM, runs clockwise<br>*West Loop:*<br>• ~65 daily runs<br>• 18 mins runtime<br>• meets every other inbound train in AM, runs clockwise; and, every other outbound departing train in PM, runs counterclockwise | N/A (No Express) |
| **ALT 5: BUS Express & Loop** | No change | Same as Alt 4 | • 92 daily runs<br>• operates 4:30AM-12:00AM<br>• headways:<br>○ 4:30AM - 6:00AM, 30 mins<br>○ 6:00AM - 7:30PM, 10 mins<br>○ 7:30 PM -12:00 AM, 30 mins |
| **ALT 6: BUS Route 45 & Loop** | No change | West Loop from Alt 4 - No East Loop | N/A (No Express) |
| | | Includes modified ROUTE 45 (different from *Loop* or *Express*) | |
| | | *Route 45* extended to Navy Yard via NRG Station<br>• extends every existing Route 45 run<br>• operates 5:06AM-2:26AM<br>• routing around Navy Yard similar to existing *Route 17* weekend Navy Yard alignment | |

**Table 8 – BSLX Scenarios Operating Assumptions**

## 6.3 O&M COST ESTIMATES

This section presents the O&M cost estimates for each alternative. The O&M cost associated with introducing the project alternative is calculated as the incremental O&M cost compared to the No Build alternative.

### NO BUILD O&M COSTS

The annual No Build baseline O&M costs to which the Build O&M costs were compared to are shown by transit mode, route, and provided in Table 9. The annual fully allocated O&M costs of transit services provided by SEPTA range from nearly $7 million for Route 45 to $101 million to provide the Broad Street Line service along its entire alignment. Note that the BSL currently does not serve The Navy Yard, while Route 45 only does so on the weekends.

The PIDC's Express and Loop shuttles are the primary transit linkages to The Navy Yard in the No Build scenario. The Navy Yard Loop replaced SEPTA's Route 71 that linked the NRG Station on SEPTA's Broad Street Line with The Navy Yard. The annual fully allocated O&M cost of providing the existing Loop service is $332,000 in 2018 dollars. The planned Loop shuttle counterclockwise service that mimics the existing clockwise service will require one additional peak fleet vehicle and incremental increases in vehicle miles and vehicle hours but is excluded from the shown total cost.

The Express shuttle bus service from Philadelphia City Center operates between 10th and Market Streets in Center City and Filbert Street to multiple bus stops within The Navy Yard development. The fully allocated O&M cost of providing this service is currently just over $1 million annually, including the cost of operating and maintaining the additional service bus beginning in 2018.

| Mode | | Operator $ per V-hour | Vehicle hours | Maint & Op. per V-mile | Vehicle miles | Overhead per peak vehicle | Peak Vehicles | Revenue | Fully Allocated Cost |
|---|---|---|---|---|---|---|---|---|---|
| **SEPTA Heavy Rail** | BSL | $22.39 | 395,645 | $2.93 | 6,805,092 | $687,100 | 105 | $36,968,030 | $100,942,911 |
| **SEPTA Bus** | Route 45 | $63.99 | 52,914 | $3.40 | 341,600 | $197,200 | 12 | $1,538,522 | $6,913,807 |
| **PIDC Shuttle Bus** | Loop | $95.11 | 3,514 | $3.40 | 47,690 | $197,200 | 1 | N/A | $331,757 |
| | Express | $92.83 | 9,598 | $3.40 | 63,252 | $197,200 | 5 | N/A | $1,020,873 |

**Table 9 – BSLX No Build Scenario O&M Costs (2018 $s)**

Sources:

SEPTA 2018 Route Statistics; SEPTA 2019 Annual Service Plan; PIDC 2018 data

Notes:

Average passenger fare for Broad Street Line shown is per car, not train. One BSL train consists of five (5) vehicles.
Overhead per peak vehicle is fully allocated and on annual basis.
SEPTA annualizes service to 255 weekdays, 52 Saturdays, and 58 Sundays (includes holidays).
Loop expansion - clockwise & counterclockwise service, assumed to be operating by 2019, excluded from O&M costs.

## BUILD ALTERNATIVES O&M COST ESTIMATES

Calculating the O&M costs for the 2040 Build alternatives comprises of generating additional peak vehicles, vehicle miles, and vehicle hours by mode and service type, and then multiplying the results by each operator's average unit cost within each cost category. The resulting cost differences in the O&M costs between the six alternatives reflect the variations in hours of service, miles of service, and vehicle fleet needs.

The estimated annual incremental O&M costs by transit mode for each of the six Build BSLX scenarios are presented in Table 10. No escalation factor is used to escalate operator costs from FY 2016 to the horizon year – the shown cost estimates are in current year 2018 dollars. A spreadsheet based high level O&M model was developed to estimate annual costs by adhering to SEPTA's three key supply variables: vehicle-hours, vehicle-miles, and the number of peak vehicles cost item.

The underlying assumption behind the allocation model is that the cost of supplying a transit service is directly related to the number of vehicle hours of service provided, the number of miles traveled, and the number of vehicles required to provide the service. This expense can be determined by apportioning SEPTA's total expenses in proportion to the number of vehicle hours, miles, and vehicles required to provide the service.

The O&M cost model calculates costs using the following equations:

> **Annual Total Incremental Expense = (Vehicle Hour-Related Expenses * Vehicle Hours) + (Vehicle Mile-Related Expenses * Vehicle Miles) + (Fixed Expenses/Vehicle * Vehicles)**

Based on the service model for the BSLX, the annual incremental O&M costs for the rail-based scenarios range from $2.2 million in Alternative 1 to over $3.7 million in Alternative 3. In terms of the potential enhanced bus options, the O&M annual price tag is lower for two scenarios, ranging from $1.5 million in Alternative 4 and close to $1.2 million in Alternative 6, but approaches the O&M cost level close to the subway scenarios in Alternative 5, with $2.9 million needed to fund the expanded Loop and Express bus network.

**The O&M costs are just part of the overall cost of enhancing and sustaining transit services. While the annual O&M costs are quite similar across the alternatives, the three rail-based alternatives include additional significant capital investment, while the bus scenarios could potentially provide similarly robust level of transit service with an increase in O&M costs only.**

| Scenario | Mode | Average Passenger Fare | New Linked Trips | Operator $ per V-hour | Vehicle hours | Maint & Op. per V-mile | Vehicle miles | Overhead - per peak vehicle | Incremental peak vehicle | Annual Revenue | Total Incremental Annual Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alt. 1** | Subway: BSLX | $1.09 | 4,600 | $22.39 | 16,182 | $2.93 | 445,823 | $101,600 | 5 | $1,830,110 | **$2,176,570** |
| **Alt. 2** | Subway: BSLX | $1.09 | 5,100 | $22.39 | 32,363 | $2.93 | 750,609 | $101,600 | 5 | $2,029,035 | **$3,431,898** |
| **Alt. 3** | Subway: BSLX | $1.09 | 4,600 | $22.39 | 32,363 | $2.93 | 851,790 | $101,600 | 5 | $1,830,110 | **$3,728,360** |
| **Alt. 4** | Bus: Loop East & West | N/A | 2,600 | $63.99 | 18,478 | $3.40 | 49,275 | $47,000 | 3 | N/A | **$1,490,950** |
| **Alt. 5** | Bus: Loop East & West | N/A | 2,900 | $63.99 | 18,478 | $3.40 | 49,275 | $47,000 | 3 | N/A | **$1,490,950** |
| | Bus: Express | | | $63.99 | 14,454 | $3.40 | 112,420 | $47,000 | 2 | N/A | **$1,401,139** |
| **Alt. 6** | Bus: Route 45 | $1.09 | 1,600 | $63.99 | 10,281 | $3.40 | 155,125 | $47,000 | 2 | $444,720 | **$834,576** |
| | Bus: Loop West | N/A | | $63.99 | 4,897 | $3.40 | 6,388 | $47,000 | 1 | N/A | **$382,082** |

**Table 10 – 2040 Build Scenarios Annual Incremental O&M Costs (2018 $s)**

Notes:

Average passenger fare for Broad Street Line shown is per car, not train. One average BSL train consists of five (5) vehicles.
Overhead per peak vehicle is incremental and on annual basis.

SEPTA annualizes service to 255 weekdays, 52 Saturdays, and 58 Sundays (includes holidays).

# 7 FINAL SCREENING AND EVALUATION

## 7.1. EVALUATED SCENARIOS

By investigating previous studies and working with key project stakeholders, the six potential alternatives were identified based on these key factors:

1. Ability to meet the project Purpose and Need
2. Existing and targeted employment and residential population within The Navy Yard
3. Transit demand and potential in South Philadelphia's sports complex area
4. Existing and proposed buildings and roadway network in The Navy Yard

Three potential horizontal subway alignments and station locations and three bus scenarios were developed for further evaluation. The scenarios were chosen based on project justification data containing population and employment data at the traffic analysis zone level (TAZ) for current year 2013 and horizon year 2040, location and magnitude of affordable housing, location and magnitude of transit-dependent populations, and supportive land use policies.

**The final screening and evaluation of the six alternatives relied on the capital and O&M cost estimates, as well as ridership and traffic volume projections from the DVRPC regional travel demand. The screening was performed to make initial determinations on eligibility for the Federal Transit Administration (FTA) New Starts funding for the three subway scenarios and cost-effectiveness and community benefit analysis for the three bus alternatives.**

## 7.2 TRAVEL DEMAND FORECASTS

### MODEL OVERVIEW

An important part of the screening development and evaluation of the considered BSLX alternatives was modeling of benefits and impacts based primarily on modeled ridership forecasts. DVRPC maintains the regional demand model used to estimate the benefits and impacts of proposed transportation projects in the region. PennDOT has contracted with DVRPC to run the model and provide forecasts in support of the evaluation of the alternatives. The modeling effort for the scenarios encompassed the following areas:

- Transit ridership
- Vehicular travel

### METHODOLOGY AND ASSUMPTIONS

#### PREPARATION PRIOR TO PERFORMING TRAVEL DEMAND FORECASTING

Prior to the execution of the DVRPC travel model, several activities took place, including getting approval from the Philadelphia City Planning Commission (PCPC) regarding total population and employment statistics for the year 2040. The PIDC estimated build-out for The Navy Yard was 2,796 persons within

1,018 residential units and an employment of 36,364. A briefing with the PCPC took place to reconcile the PIDC estimates against the overall area's growth rate, resulting into the following 2040 estimates which were subsequently approved by DVRPC: population of 1,609 and employment of 28,175.

Concurrently with these discussions, a stated preference survey was undertaken to understand the travel market characteristics of the potential users in The Navy Yard. An interactive online survey was developed to gain public input and determine commuting patterns for employees in The Navy Yard as well as an on-site survey from October 22, 2015 to January 4, 2016 (shown in Figure 24). Over 2,000 visits to the website yielded 1,200 valid survey responses. These findings were used to calibrate the DVRPC travel forecasting model at the sub-area level.


Figure 24 – Navy Yard On-Site Survey

One of the more informative results was the points of origins data for commuters to The Navy Yard. As shown in Figure 26, they are distributed across the greater Philadelphia region but mainly clustered around South Philadelphia's neighborhoods as well as Fishtown and Kensington neighborhoods in North Philadelphia.

These findings were used to calibrate the DVRPC travel forecasting model at the sub-area level and develop horizon year origins of person-trips to The Navy Yard. As shown in Figure 27, the trip origins to The Navy Yard are projected to continue being concentrated in the City of Philadelphia, and especially its south and southeast neighborhoods.

Some other relevant survey findings included insights on the commuting modes, with 65% of employees reportedly driving alone to The Navy Yard, 3% carpooling, 20% using SEPTA, and 7% taking The Navy Yard Express shuttle. Roughly 86% of employees reported commuting less than 60 minutes to the place of work and the majority commute less than 35 minutes, as shown in Figure 25. Over 57% of respondents were between the ages of 18 and 34, with the most common employers listed being the Department of Defense (U.S. Navy), Urban Outfitters, and Aker.

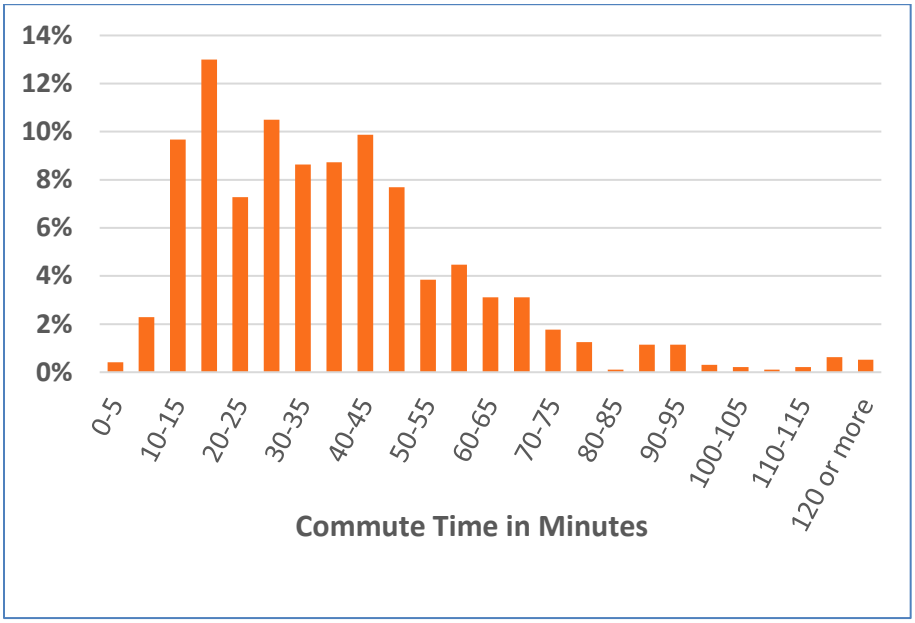



Figure 25 – Navy Yard On-Line Survey: Commuting Time

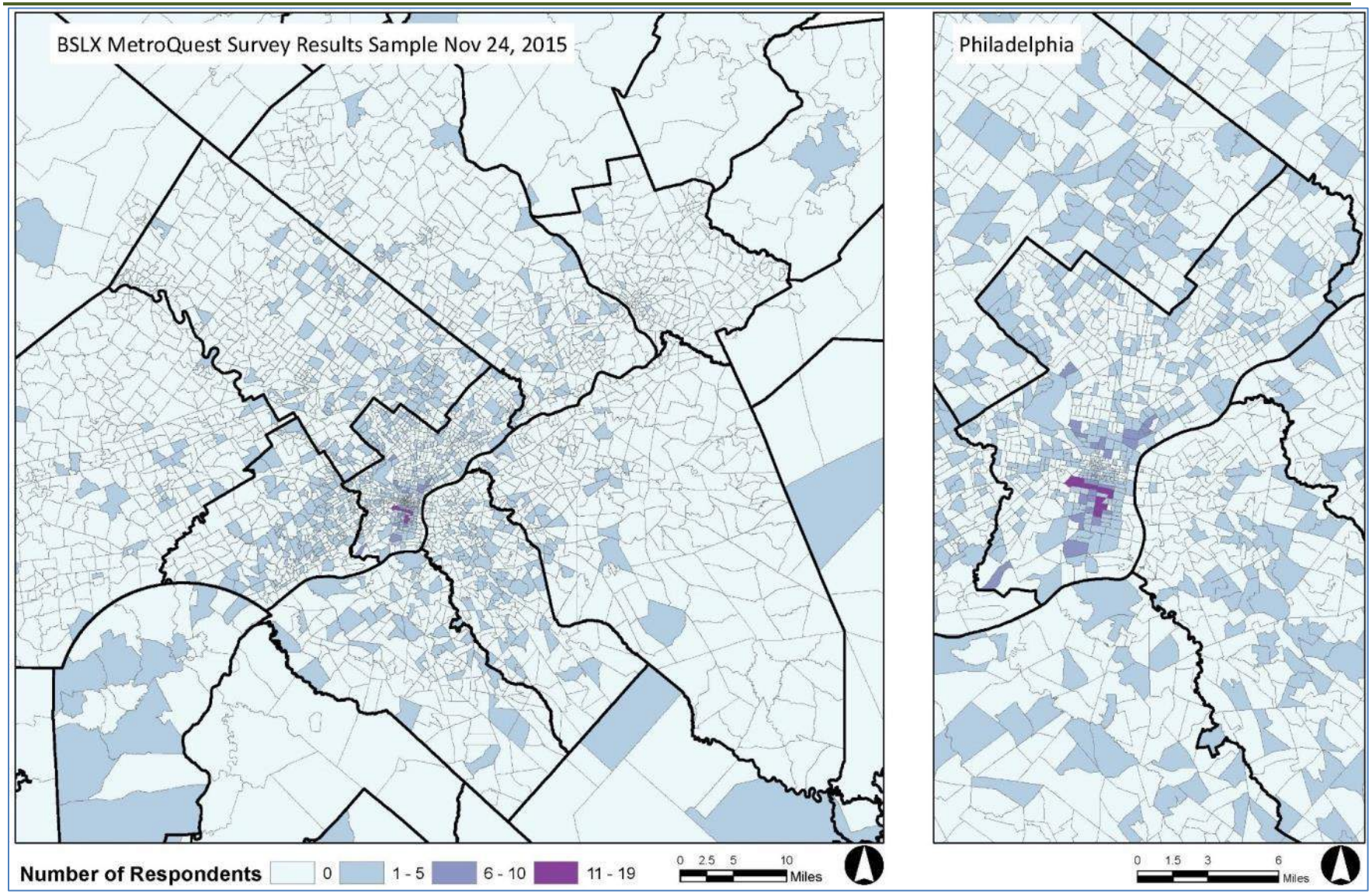



Figure 26 – Navy Yard On-Line Survey: Trip Origins

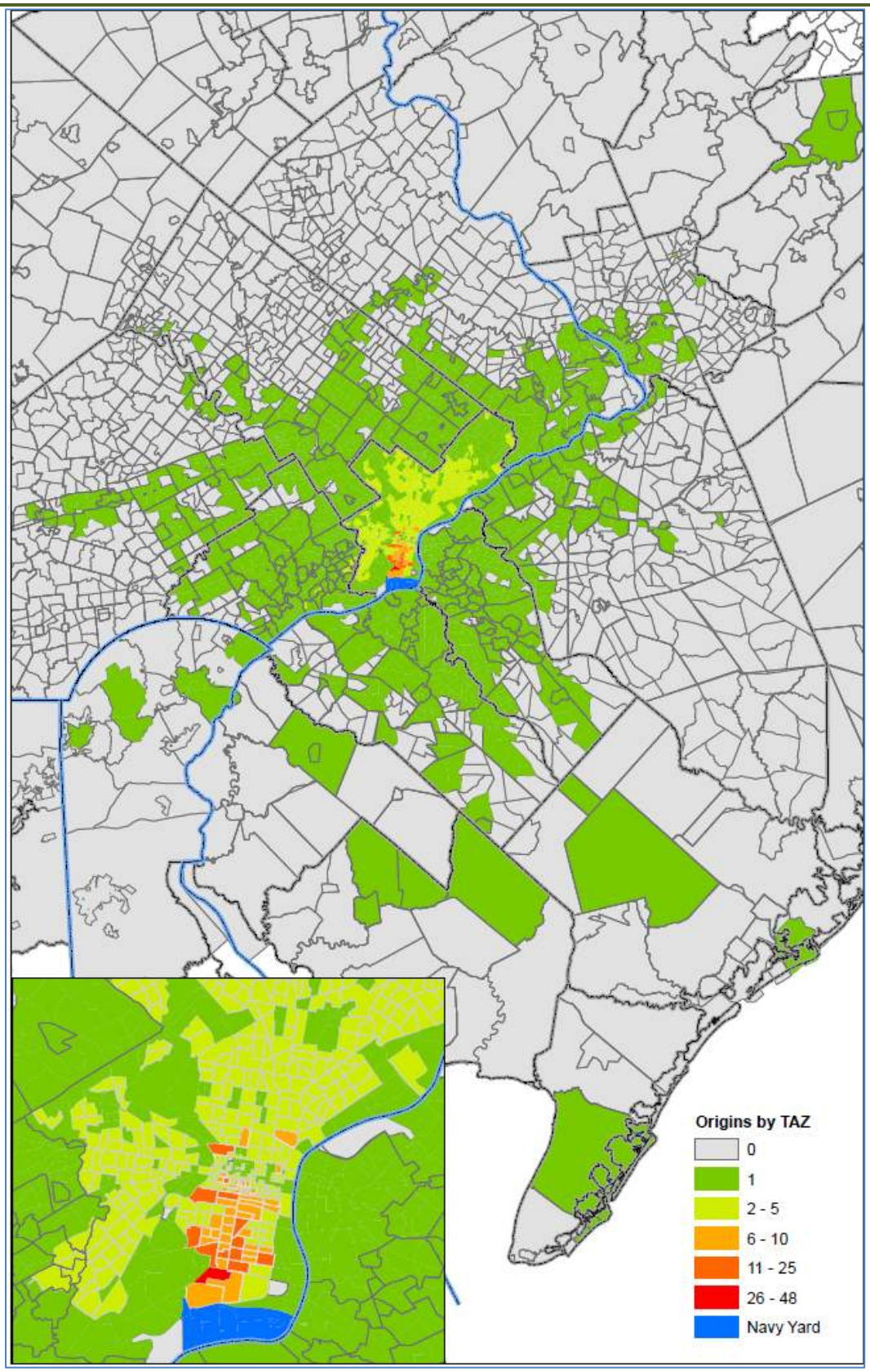



Figure 27 - Navy Yard Projected Origins of Person-Trips

**MODELING ASSUMPTIONS**

DVRPC's current Travel Improvement Model version 2.2 (TIM) was used to analyze this project. The TIM is a traditional four-step (Trip Generation, Trip Distribution, Mode Choice, and Assignment) trip-based model, built on the VISUM software platform. The four-step procedures are used to estimate average daily transit ridership and highway traffic volumes, primarily based on calibrated existing travel conditions, as well as forecasts of study area socio-demographics, land use assumptions, and projected highway and transit improvements.

A full description of the methodology and assumptions used by DVRPC to model travel demand for the BSLX scenarios is included in Appendix E, with key assumptions as follows:

- The base year was 2013 and the horizon year for forecasts was 2040.
- The modeled scenarios included:
    - 2013 No Build scenario for calibration purposes. It included major roadway improvements constructed prior to, or during 2013. The transit network reflects the transit routes, schedules and fares in effect in 2013.
    - 2040 No Build scenario: includes projected land use growth from 2013 to 2040, as well as planned and funded highway and transit improvements, except for the Broad Street Line extension.
    - Three rail-based 2040 Build scenarios. These scenarios extend the existing Broad Street Line from its current southern termini at NRG Station to The Navy Yard: They include the 2040 No Build elements, plus the subway extension and/or bus enhancements, depending on the scenario:
        - ALTERNATIVE 1: ROUSE BOULEVARD with one proposed station along Rouse Boulevard near Central Green. Enhanced East and West Loop bus feeder service is included.
        - ALTERNATIVE 2: 13TH STREET AND CONSTITUTION AVENUE alignment includes the proposed stations near the intersection of 13th Street and Intrepid Avenue, and on Kitty Hawk Avenue east of League Island Boulevard intersection. Enhanced East and West Loop bus feeder service is included.
        - ALTERNATIVE 3: BROAD STREET AND KITTY HAWK AVENUE alignment includes the proposed stations along Broad Street, adjacent to the Marine Parade Grounds between Intrepid Avenue and Constitution Avenue, and on Kitty Hawk Avenue east of League Island Boulevard intersection. Enhanced East and West Loop bus feeder service is included.
    - Three enhanced bus 2040 Build alternatives (these scenarios assume no change in heavy rail service, with BSL subway terminating at NRG Station):
        - ALTERNATIVE 4: LOOP enhances the existing Loop by increasing service frequency and service hours on this route's East and West Loop variations. Supporting bus service characteristics are similar the heavy rail scenarios except for minor routing adjustments due to lack of new BSL stations serving The Navy Yard. The existing Express shuttle service is discontinued.

- ALTERNATIVE 5: EXPRESS & LOOP enhances the existing Loop by increasing service frequency and service hours. It also enhances the Express route connecting Center City to/from The Navy Yard via the I-95.
- ALTERNATIVE 6: ROUTE 45 & LOOP extends every existing run of SEPTA Route 45 bus to The Navy Yard and modifies the Route to mirror the existing SEPTA Route 17 weekend Navy Yard south of the NRG BSL station. It discontinues the existing Express shuttle service.

- The Operating Plan parameters such as: headways, service frequency, service span, operating speed, distance, travel time, recovery time, and peak vehicles were used as input assumptions in the travel demand model.
- The model area includes DVRPC's nine designated MPO counties (Pennsylvania's Bucks, Chester, Delaware, Montgomery, and Philadelphia counties; and New Jersey's Burlington, Camden, Gloucester, and Mercer counties), and an extended regional area (additional outlying Pennsylvania, New Jersey, Delaware, and Maryland counties).

Within The Navy Yard area, the focus was on reporting ridership for the 22 Traffic Analysis Zones (TAZs) that comprise the City of Philadelphia's Lower South District. The Navy Yard is part of the Lower South District and includes seven of those TAZs: 1801,1802,1803,1804,1805,1806, and 1807, shown in Figure 28.

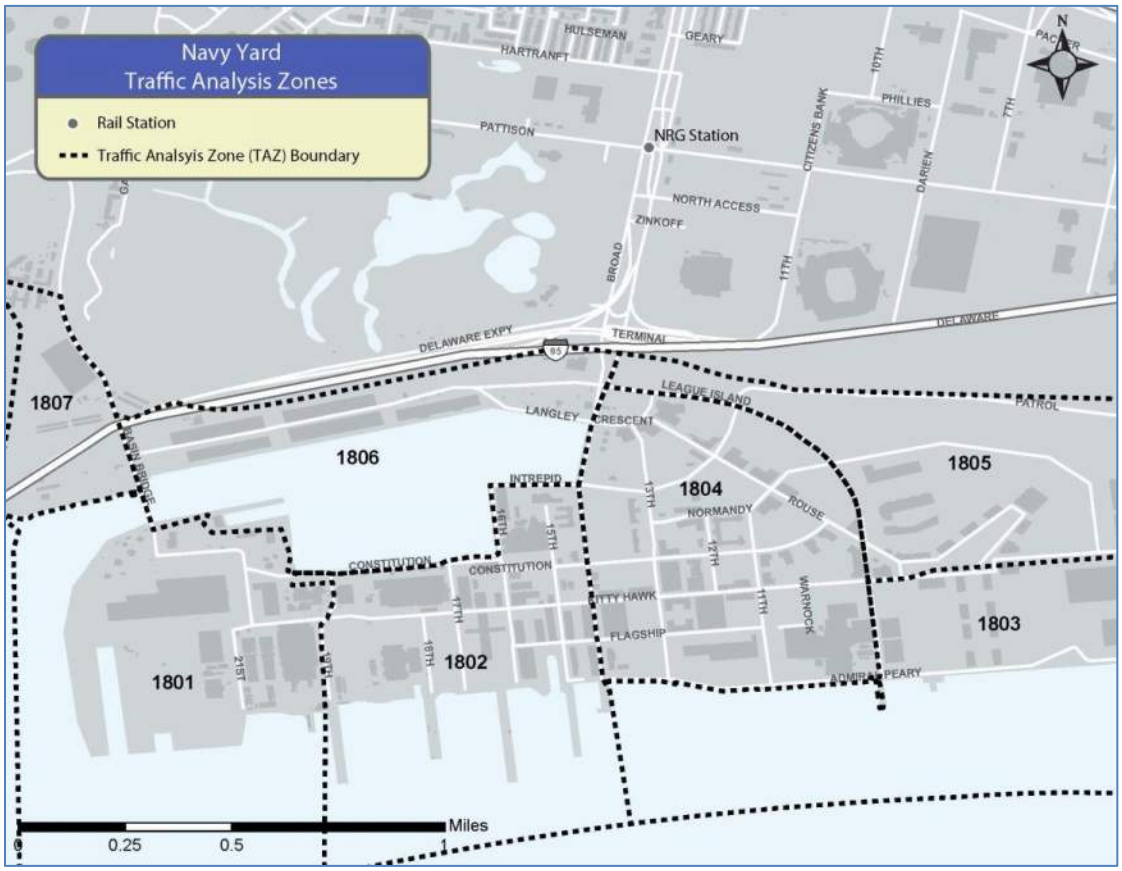



Figure 28 – Navy Yard TAZs

The TIM outputs include forecast ridership, highway and vehicular travel, and air quality. Model outputs are produced for four different daily times (AM peak, midday, PM peak, or evening), various trip purposes (e.g., home-based work, homebased non-work, non-home-based trips), and multiple service users (non-transit dependents and transit dependents – low-income riders). Summary-level data - for an entire day and by trip purpose – is presented in this report, with focus on highlighting differences between the No Build and Build scenarios.

### RIDERSHIP FORECASTS

The TIM produced several key transit ridership indicators, including:

- **Linked trips on project**:
  A linked trip represents a rider traveling from origin to destination, including necessary transfers. It counts as a single trip regardless of the number of transfers. For BSLX, linked project trips meet one or more of the following criteria:
  - A trip that uses the BSL extension to The Navy Yard for some portion of its journey
  - A trip on a local or express bus route or bus shuttle that boards or alights at a proposed BSL station in The Navy Yard.

  Based on these criteria, the number of daily linked trips on the project ranges from a high of 11,400 trips in 2040 Build Alternative 2, to a low of 7,900 trips in Alternative 6 (Table 11).
- **New trips on project:**
  A new trip generated by a project is the difference in the number of linked trips between the No Build and Build scenarios. This is yet another metric used in the New Starts evaluation. The forecasted incremental change in new trips between the 2040 No Build and the 2040 Build scenarios ranges from a low of 1,600 daily trips for Alternative 6 to 5,100 daily trips for Alternative 2 (Table 11). This represents a 27 to 81% overall increase over the No Build scenario, respectively.

  If the BSLX project advances to a development phase, the number of forecasted linked trips and new trips on project would be used to support the Federal Transit Administration (FTA) New Starts project justification evaluation metrics including mobility benefits and cost-effectiveness.

- **Unlinked trips**:

  An unlinked trip represents an individual transit segment ride: a single trip on the BSL or a single feeder bus shuttle trip. Several unlinked trips may form a linked trip when a transfer is involved to reach a destination. The difference in unlinked trips between the No Build and Build scenarios highlights the magnitude of new transit boardings generated by the project across the entire (or portion of) transit network.

  The number of additional daily unlinked trips on select transit lines in the region (SEPTA's two heavy rail and all regional rail lines, as well as bus routes serving The Navy Yard) is the greatest for Alternative 4, with over 5,800 incremental unlinked trips above the No Build scenario (Table 12). Alternative 5 is slightly less, generating over 5,500 additional unlinked trips for the transit network segments in question. Other scenarios also result in net gains in the number of regional

unlinked transit trips. This forecast indicates that with the implementation of the Broad Street Line Extension, overall transit ridership in the region would increase, and bus scenarios – when implemented - are likely to generate more need for transfers to reach the final destinations.

- **Boardings by station:**

Under the Build scenarios, boardings along the Broad Street Line inclusive and south of the City Hall indicate a more robust transit increase, with over 5,500 additional daily boardings projected for Alternative 2 (a 9% ridership increase over the No Build forecast), and slightly less for Alternative 3, as shown in Table 13.

Notably, if implemented, at the station level, the proposed subway extension is projected to slightly increase the number of boardings at the BSL stations in Center City but would also divert more than half of the existing trips from its southern termini, the NRG Station (Table 14). Many of those trips (approximately 1,600 per each subway Build scenario) would be diverted to the potential Navy Yard station(s) instead and would not count as new trips. The bus scenarios result in increased boardings at the NRG and Oregon Avenue BSL Stations.

| Scenario | Mode | 1801 | 1802 | 1803 | 1804 | 1805 | 1806 | 1807 | TOTAL | Change from No Build | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2040 No Build** | Bus | 300 | 600 | 500 | 2,300 | 500 | 200 | 200 | **4,700** | | |
| | BRT / Express | 0 | 100 | 200 | 1,100 | 100 | 100 | 0 | 1,600 | | |
| | **TOTAL** | **400** | **800** | **800** | **3,400** | **700** | **200** | **200** | **6,300** | | |
| **2040 Build Alt 1** | Bus | 500 | 600 | 1,100 | 900 | 600 | 100 | 200 | 4,000 | | |
| | Subway | 0 | 600 | 500 | 5,100 | 500 | 100 | 0 | 6,900 | | |
| | **TOTAL** | **500** | **1,200** | **1,600** | **6,000** | **1,100** | **200** | **200** | **10,900** | **4,600** | **73%** |
| **2040 Build Alt 2** | Bus | 400 | 400 | 700 | 800 | 300 | 100 | 200 | 2,900 | | |
| | Subway | 100 | 900 | 1,300 | 4,800 | 1,200 | 200 | 0 | 8,500 | | |
| | **TOTAL** | **500** | **1,300** | **2,000** | **5,600** | **1,400** | **200** | **200** | **11,400** | **5,100** | **81%** |
| **2040 Build Alt 3** | Bus | 300 | 200 | 800 | 1,100 | 200 | 100 | 200 | 2,800 | | |
| | Subway | 200 | 1,200 | 1,300 | 4,000 | 1,300 | 200 | 0 | 8,100 | | |
| | **TOTAL** | **500** | **1,500** | **2,100** | **5,000** | **1,400** | **300** | **200** | **10,900** | **4,600** | **73%** |
| **2040 Build Alt 4** | Bus | 400 | 1,100 | 1,600 | 4,200 | 1,100 | 200 | 200 | 8,900 | | |
| | BRT / Express | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | **TOTAL** | **400** | **1,100** | **1,600** | **4,200** | **1,100** | **200** | **200** | **8,900** | **2,600** | **41%** |
| **2040 Build Alt 5** | Bus | 400 | 900 | 1,400 | 3,500 | 800 | 200 | 200 | 7,400 | | |
| | BRT / Express | 0 | 200 | 300 | 800 | 300 | 0 | 0 | 1,800 | | |
| | **TOTAL** | **400** | **1,200** | **1,700** | **4,300** | **1,200** | **200** | **200** | **9,200** | **2,900** | **46%** |
| **2040 Build Alt 6** | Bus | 400 | 1,000 | 1,100 | 3,900 | 600 | 200 | 200 | 7,400 | | |
| | BRT / Express | 0 | 0 | 300 | 300 | 0 | 0 | 0 | 600 | | |
| | **TOTAL** | **400** | **1,000** | **1,400** | **4,100** | **600** | **200** | **200** | **7,900** | **1,600** | **27%** |

Table 11 - Daily Linked Transit Trips to/from Navy Yard TAZs

| Transit Line | 2040 No Build | 2040 Build Alt 1 | 2040 Build Alt 2 | 2040 Build Alt 3 | 2040 Build Alt 4 | 2040 Build Alt 5 | 2040 Build Alt 6 |
|---|---|---|---|---|---|---|---|
| **Subway:** | | | | | | | |
| **Broad Street Line** | **139,278** | **143,068** | **145,370** | **145,204** | **142,641** | **141,311** | **140,340** |
| Market Frankford | 193,598 | 194,111 | 194,325 | 194,309 | 193,866 | 194,108 | 193,572 |
| Subtotal | 332,876 | 337,179 | 339,695 | 339,513 | 336,507 | 335,419 | 333,912 |
| **Regional Rail:** | | | | | | | |
| AIR (Airport Line) | 1,931 | 1,935 | 1,929 | 1,931 | 1,931 | 1,931 | 1,930 |
| CHE (Chestnut Hill East Line) | 5,114 | 5,123 | 5,117 | 5,117 | 5,112 | 5,115 | 5,107 |
| CHW (Chestnut Hill West Line) | 4,770 | 4,766 | 4,761 | 4,763 | 4,778 | 4,776 | 4,779 |
| CYN (Cynwyd Line) | 1,117 | 1,114 | 1,113 | 1,112 | 1,121 | 1,118 | 1,122 |
| DOY (Lansdale/Doylestown Line) | 9,581 | 9,604 | 9,592 | 9,590 | 9,590 | 9,591 | 9,575 |
| ELW (Media/Elwyn Line) | 11,847 | 11,813 | 11,826 | 11,828 | 11,807 | 11,800 | 11,839 |
| FOX (Fox Chase Line) | 4,723 | 4,728 | 4,729 | 4,729 | 4,727 | 4,725 | 4,728 |
| NOR (Manayunk/Norristown Line) | 11,000 | 11,007 | 11,012 | 11,008 | 10,989 | 10,992 | 10,977 |
| PAO (Paoli/Thorndale Line) | 25,353 | 25,362 | 25,362 | 25,360 | 25,351 | 25,348 | 25,346 |
| TRE (Trenton Line) | 11,488 | 11,584 | 11,566 | 11,562 | 11,525 | 11,521 | 11,464 |
| WAR (Warminster Line) | 9,395 | 9,407 | 9,399 | 9,398 | 9,387 | 9,390 | 9,395 |
| WIL (Wilmington/Newark Line) | 11,553 | 11,612 | 11,609 | 11,595 | 11,593 | 11,569 | 11,520 |
| WTR (West Trenton Line) | 12,845 | 12,847 | 12,854 | 12,849 | 12,824 | 12,824 | 12,831 |
| Subtotal | 120,717 | 120,902 | 120,869 | 120,842 | 120,735 | 120,700 | 120,613 |
| **Bus:** | | | | | | | |
| SEPTA Route 45 | 6,570 | 6,793 | 6,617 | 6,659 | 6,504 | 6,504 | 11,056 |
| **Navy Yard Express** | **1,452** | | | | | **2,145** | |
| **Navy Yard Loop** | **4,115** | **2,796** | **1,757** | **1,725** | **7,832** | **6,511** | **1,805** |
| Subtotal | 12,137 | 9,589 | 8,374 | 8,384 | 14,336 | 15,160 | 12,861 |
| Total | 465,730 | 467,670 | 468,938 | 468,739 | 471,578 | 471,279 | 467,386 |
| ***Change from No Build*** | | **1,940** | **3,208** | **3,009** | **5,848** | **5,549** | **1,656** |
| | | **0.4%** | **0.7%** | **0.6%** | **1.3%** | **1.2%** | **0.4%** |

Table 12 - Daily Unlinked Transit Trips on Select Routes

| BSL Station | 2040 No Build | 2040 Build Alt 1 | 2040 Build Alt 2 | 2040 Build Alt 3 | 2040 Build Alt 4 | 2040 Build Alt 5 | 2040 Build Alt 6 |
|---|---|---|---|---|---|---|---|
| City Hall | 28,096 | 28,779 | 28,868 | 28,785 | 28,413 | 27,989 | 28,097 |
| Walnut-Locust | 10,338 | 10,445 | 11,060 | 11,061 | 10,964 | 10,887 | 10,817 |
| Lombard-South | 5,133 | 5,226 | 5,274 | 5,272 | 5,214 | 5,191 | 5,116 |
| Ellsworth-Federal | 3,086 | 3,095 | 3,199 | 3,202 | 3,183 | 3,183 | 3,159 |
| Tasker-Morris | 5,569 | 5,494 | 5,715 | 5,717 | 5,685 | 5,681 | 5,619 |
| Snyder Ave | 6,287 | 6,336 | 6,468 | 6,426 | 6,331 | 6,325 | 6,187 |
| Oregon Ave | 3,711 | 3,979 | 4,155 | 4,201 | 4,053 | 4,047 | 3,847 |
| NRG | 2,849 | 1,259 | 1,289 | 1,291 | 4,120 | 3,456 | 3,038 |
| **Rouse Blvd-Central Green** | | **4,149** | | | | | |
| **13th Street** | | | **3,267** | | | | |
| **Kitty Hawk Ave** | | | **1,288** | **1,288** | | | |
| **Marine Parade Grounds-Broad St** | | | | **3,056** | | | |
| **Total** | **65,067** | **68,761** | **70,582** | **70,297** | **67,961** | **66,757** | **65,878** |
| ***Change from No Build*** | | ***3,694*** | ***5,515*** | ***5,230*** | ***2,894*** | ***1,690*** | ***811*** |
| | | ***5.7%*** | ***8.5%*** | ***8.0%*** | ***4.4%*** | ***2.6%*** | ***1.2%*** |

Table 13 – Broad Street Line Station Level Daily Boardings (South of City Hall)

| BSL Station | 2040 Build Alt 1 | 2040 Build Alt 2 | 2040 Build Alt 3 | 2040 Build Alt 4 | 2040 Build Alt 5 | 2040 Build Alt 6 |
|---|---|---|---|---|---|---|
| City Hall | 2.4% | 2.7% | 2.5% | 1.1% | -0.4% | 0.0% |
| Walnut-Locust | 1.0% | 7.0% | 7.0% | 6.1% | 5.3% | 4.6% |
| Lombard-South | 1.8% | 2.7% | 2.7% | 1.6% | 1.1% | -0.3% |
| Ellsworth-Federal | 0.3% | 3.7% | 3.8% | 3.2% | 3.1% | 2.4% |
| Tasker-Morris | -1.3% | 2.6% | 2.7% | 2.1% | 2.0% | 0.9% |
| Snyder Avenue | 0.8% | 2.9% | 2.2% | 0.7% | 0.6% | -1.6% |
| Oregon Avenue | 7.2% | 12.0% | 13.2% | 9.2% | 9.0% | 3.7% |
| NRG | -55.8% | -54.8% | -54.7% | 44.6% | 21.3% | 6.6% |

Table 14 – Broad Street Line Station Level Daily Boardings compared to No Build

## VEHICULAR TRAVEL FORECASTS

Roadways within the project area include Broad Street, League Island Boulevard, Crescent Drive, Rouse Boulevard, South 11th Street, South 12th Street, South 13th Street, Intrepid Avenue, Normandy Place, Constitution Avenue, and Kitty Hawk Avenue. An Interstate 95 overpass crosses Broad Street within the BSLX project area, just north of The Navy Yard. The Navy Yard roadway network is assumed to remain as existing in the future year Build scenarios, outside of a few known changes:

- Broad Street, between Crescent Drive and Intrepid Avenue, is being reconstructed and returned to two-lanes in each direction
- Langley Avenue is being relocated - its intersection with Crescent Drive is being removed and moved one block north to align with League Island Boulevard
- New streets to facilitate access to proposed development in the eastern sections of The Navy Yard

DVRPC is responsible for collecting counts of vehicular traffic volumes at more than 5,000 locations regionwide. Average daily traffic (ADT) volume is automatically recorded in 15-minute intervals with pneumatic road tubes and reported on an hourly basis. The data is available through an interactive ESRI's ArcGIS website, where cordon point data can be observed at specific traffic count locations. Vehicular access to The Navy Yard itself is assumed to continue to be limited to just two ingress and egress access roadways: Broad Street and 26th Street. The following traffic counts for the two access roadways were collected in January 2015:

- A: South Broad Street – 16,900
- B: 26th Street – 3,600

Therefore, the daily two-way volume crossing this screenline is equal to 20,500 vehicles. These counts were used to calibrate the 2013 Base Year travel demand model. The corresponding daily model volume crossing this screenline is 20,650, approximately 0.7 percent higher than the count. The 2040 horizon year travel demand was developed using the projected employment and population growth and travel patterns in the area.

The TIM produces several key indicators related to highway and vehicular travel, including:

### AVERAGE DAILY TRAFFIC

The regional travel demand model projects lower vehicular traffic speeds in the area, thus affecting the travel times. Table 15 summarizes the morning and afternoon peak hour traffic forecasts for The Navy Yard's access roadway segments (shown in Figure 29).

In comparison to the No Build alternative, the Build scenarios would generally result in a slight decrease in ADT within The Navy Yard, with Alternative 2 providing the greatest congestion relief benefit between the analyzed rail alternatives, and Alternative 4 providing the greatest benefit between the three bus scenarios.

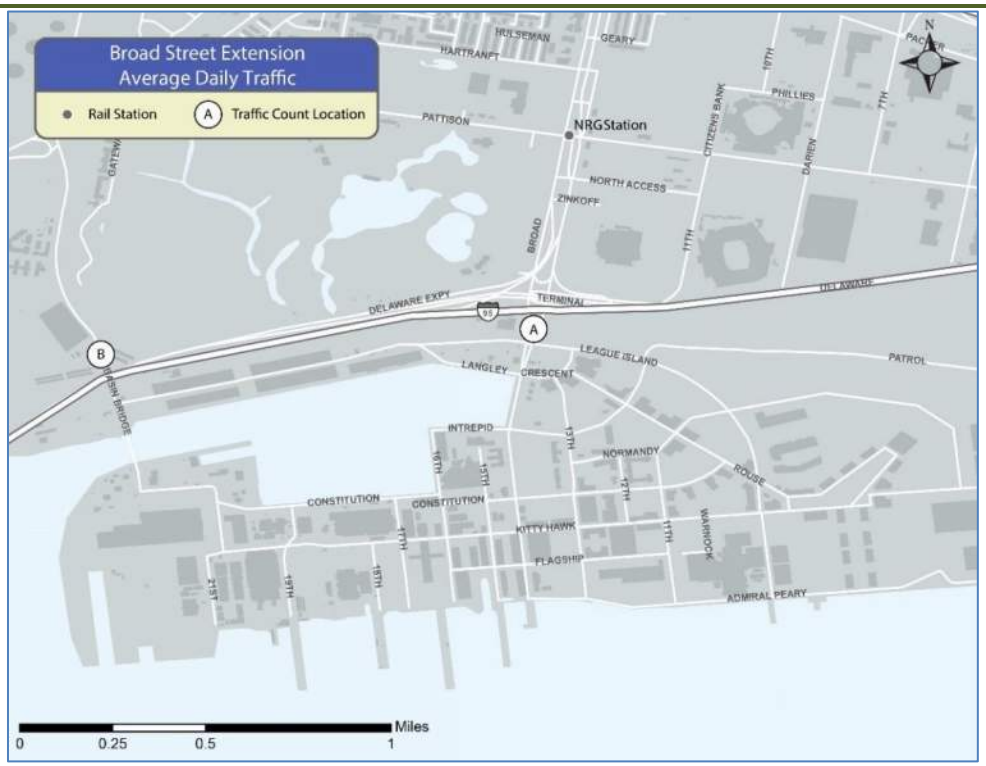



Figure 29 – Traffic Count Locations

| | Street | Location | 2013 Count | 2013 Base | 2040 No Build | Build Alt 1 | Build Alt 2 | Build Alt 3 | Build Alt 4 | Build Alt 5 | Build Alt 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **AM Peak Period (6:00AM to 10:00AM) Inbound Vehicle Trips to The Navy Yard:** | | | | | | | | | | | |
| **A*** | Broad St | North of League Island Blvd | 4,700 | 4,200 | 12,700 | 11,500 | 11,500 | 11,600 | 12,300 | 12,200 | 12,600 |
| B* | 26th St | North of Langley Ave | 800 | 1,000 | 1,300 | 1,300 | 1,300 | 1,300 | 1,300 | 1,300 | 1,300 |
| **Total AM Inbound** | | | 5,500 | 5,200 | 14,000 | 12,800 | 12,800 | 12,900 | 13,600 | 13,500 | 13,900 |
| **PM Peak Period (3:00PM to 7:00PM) Outbound Vehicle Trips from The Navy Yard:** | | | | | | | | | | | |
| A* | Broad St | North of League Island Blvd | 4,600 | 4,100 | 11,900 | 11,000 | 10,800 | 10,900 | 11,500 | 11,500 | 11,700 |
| B* | 26th St | North of Langley Ave | 1,000 | 1,100 | 1,600 | 1,600 | 1,600 | 1,600 | 1,600 | 1,600 | 1,600 |
| **Total PM Outbound** | | | 5,600 | 5,200 | 13,500 | 12,600 | 12,400 | 12,500 | 13,100 | 13,100 | 13,300 |

Table 15: AM and PM Peak Periods Navy Yard Traffic Summary

*Nodes A and B represent access/egress roadway segments to The Navy Yard.

### VEHICLE-MILES OF TRAVEL

Vehicle-Miles of Travel, or VMT, is an estimate of the total amount of travel measured by distance by cars and trucks on the regional highway system. If accessible and convenient to use, transit projects tend to reduce VMT due to induced trips - the shift away from the automobile to transit; as the New Starts process illustrates, VMT reduction leads to measurable environmental benefits and impact automobile emissions and energy consumption.

The change in daily VMT in 2040 for the entire regional TIM area resulting from the proposed alternatives ranges from a reduction of over 76,000 in Alternative 2, to an increase of 17,000 in Alternative 5 (Table 16). At the regional scale, these VMT impacts are negligible (less than 0.1% overall impact) but would contribute to slightly lower (subway alternatives and bus scenario 4) or slightly higher (bus scenarios 5 and 6) energy consumption and emissions locally within The Navy Yard.

| VMT | 2040 No Build | 2040 Build Alt 1 | 2040 Build Alt 2 | 2040 Build Alt 3 | 2040 Build Alt 4 | 2040 Build Alt 5 | 2040 Build Alt 6 |
|---|---|---|---|---|---|---|---|
| Total | 251,200,041 | 251,173,058 | 251,123,594 | 251,149,252 | 251,132,429 | 251,217,405 | 251,207,595 |
| *Change from No Build* | | *-26,983* | *-76,448* | *-50,790* | *-67,612* | *17,364* | *7,554* |
| | | *-0.011%* | *-0.030%* | *-0.020%* | *-0.027%* | *0.007%* | *0.003%* |

**Table 16 – Projected Change in Daily Regional VMT**

### CAPACITY ANALYSIS

Capacity analysis was conducted for the two Navy Yard access roadway segments (Table 17). Volume-to-capacity ratio (V/C) is expected to be positively impacted by the potential subway extension, with Broad Street north of League Island Boulevard (southbound direction) projected to improve the most under the Alternative 2 scenario. The other two heavy rail alignments are slightly behind Scenario 2 but would also improve V/C ratio within The Navy Yard. The bus scenarios are projected to have a less significant effect on mitigating vehicular congestion.

| Street | Location | Direction | 2013 BASE | 2040 NB | BUILD ALT 1 | BUILD ALT 2 | BUILD ALT 3 | BUILD ALT 4 | BUILD ALT 5 | BUILD ALT 6 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Broad Street** | North of League Island | NB | 0.14 | 0.43 | 0.41 | 0.41 | 0.42 | 0.42 | 0.42 | 0.43 |
| | | SB | 0.70 | 2.08 | 1.90 | 1.89 | 1.91 | 2.02 | 2.00 | 2.07 |
| **26th Street** | North of Langley | NB | 0.11 | 0.17 | 0.19 | 0.18 | 0.19 | 0.19 | 0.19 | 0.18 |
| | | SB | 0.56 | 0.84 | 0.87 | 0.85 | 0.87 | 0.84 | 0.85 | 0.85 |

**Table 17 – Volume-to-Capacity Ratio AM Peak Period Estimates**

## 7.3 HEAVY RAIL ALTERNATIVES FEASIBILITY SCREENING

### FEASIBILITY SCREENING OVERVIEW

The 2040 horizon year ridership and traffic volumes output from the DVRPC travel forecasting model and capital and O&M cost estimates for the identified potential alignments served as inputs to assess feasibility and make some determinations on whether the capital intensive potential subway scenario extensions (not the bus scenarios) might be eligible for Federal Transit Administration (FTA) New Starts funds. The high-level screening investigates the three subway scenarios' cost-effectiveness to increase transit accessibility, potential to improve area mobility, increase transit ridership, improve air quality, ensure fair distribution of transit services, and support opportunities for economic development.

This high-level feasibility study examines the alternatives at a concept level only. To be consistent with FTA guidelines for a Major Investment Study, this study utilizes elements of FTA's New Starts program methodology to assess how well the BSLX would score and compete if federal funding was sought in the future.

Projects seeking New Starts funding complete a series of steps over several years to be eligible for funding. If the BSLX project moves forward and a construction grant is sought, it would need to comply with the New Starts process that specifies three points at which project evaluation and rating occurs (as shown in Figure 30):

1. Entry into Project Development;
2. Entry into Engineering, and
3. Entry into a Full Funding Grant Agreement (FFGA)

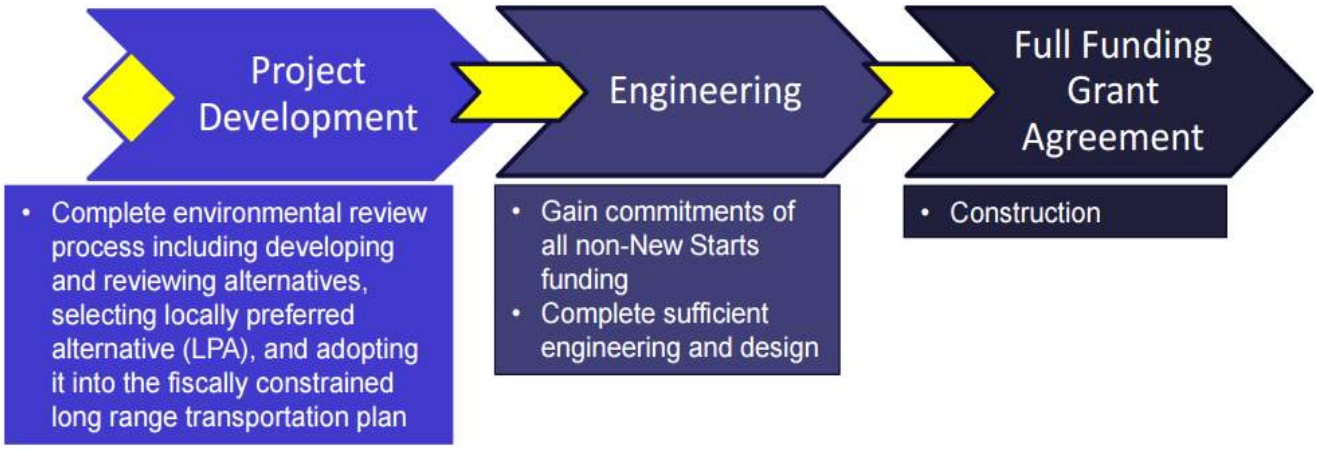



Figure 30 - New Starts Evaluation Process

## NEW STARTS PROJECT JUSTIFICATION CRITERIA

FTA's evaluation and rating of candidate projects depend upon the completion of applications with detailed analysis and reporting of a project's estimated ridership, operating costs and the project's economic, financial, and planning contexts. Criteria for rating projects fall into two broad categories (shown in Figure 31):

1. Project Justification
2. Local Financial Commitment

Each criterion is ranked on a five-point scale running from low to high: low, medium-low, medium, medium-high, and high. An overall medium ranking is needed in both categories for a medium project rating.

Ridership estimates, network traffic volumes, and cost estimates are used to evaluate the project based on the following New Starts project justification criteria:

- Mobility Benefits - based upon estimated annual ridership
- Cost-Effectiveness - based upon the estimated project's cost (for annualized capital and operations and maintenance costs) on a per trip basis
- Environmental Benefits - reflecting changes in VMT due to implementation of a proposed project and impacts on greenhouse gas emissions.

The three remaining project justification criteria are assessed in different ways:

- Congestion Relief – assessed qualitatively by comparing total weekday linked transit trips for the No Build alternative with total weekday linked transit trips on the project;
- Economic Benefits - assessed qualitatively based upon the supply and effectiveness of transit and affordable housing supportive plans and policies in the project corridor;
- Land Use - assessed quantitatively using population densities within half a mile of the stations, total employment served by a project, parking supply and cost in a candidate project region's Central Business District (CBD), and the share of "legally binding affordability restricted" (LBAR) housing in a project area compared to such housing in the surrounding counties.

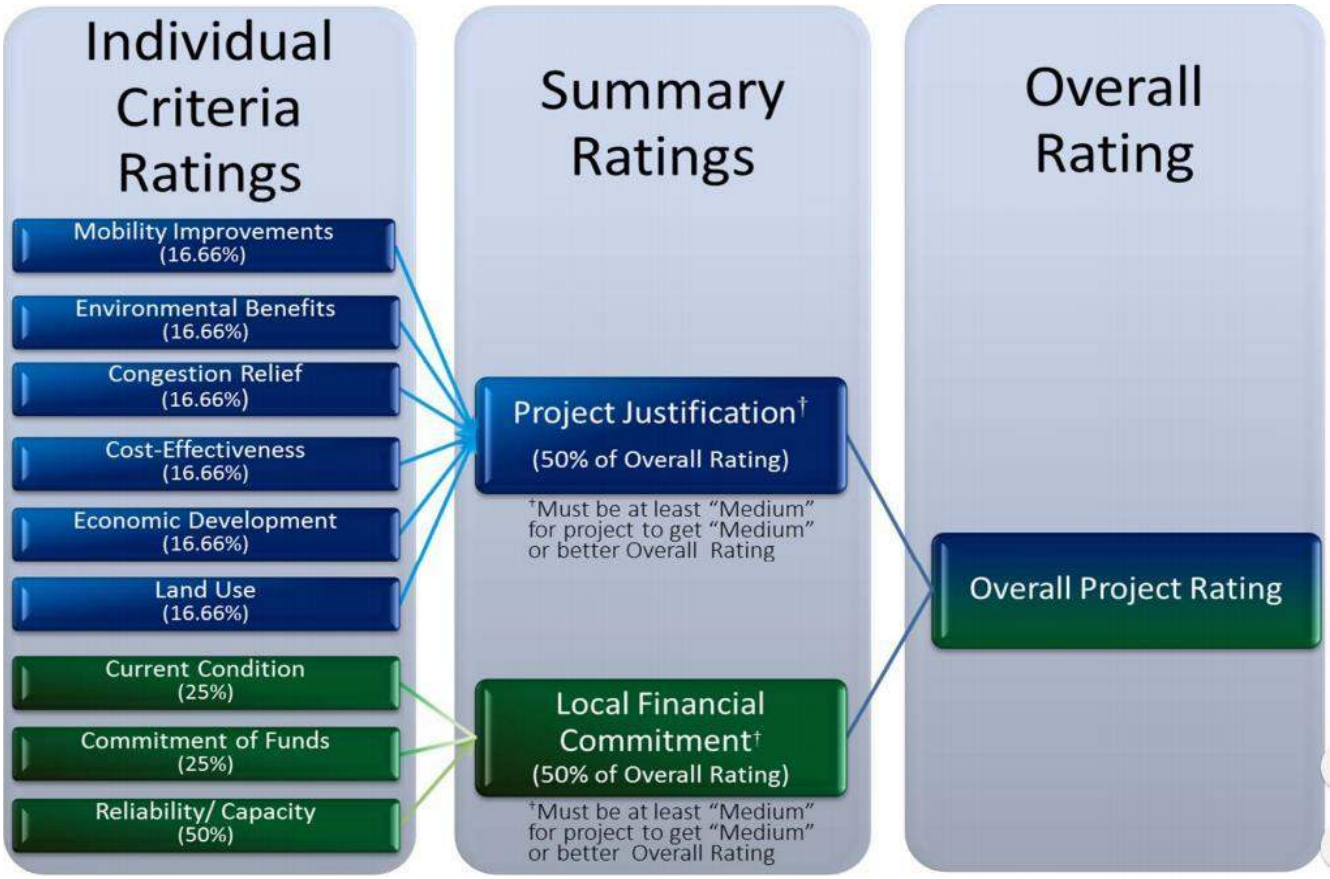



Figure 31 - New Starts Rating Criteria

FTA has established breakpoints for each criterion's rating based upon available recommended distinct values or performance criteria derived from previously and/or currently in the Capital Investment Grants (CIG) program. FTA requires all project sponsors to calculate the measures for the evaluation criteria based on current year inputs of population and employment and the opening year service plan of the proposed project but allows project sponsors to calculate evaluation criteria based upon a horizon year if those projections are averaged with the current year values.

**The Phase 2 Feasibility Study only estimates ridership projections for the future year build scenarios. To comply with the FTA New Starts requirements to compete for project funding, the existing year Build scenarios ridership forecasts would need to be provided for this project to advance beyond its initial phase.**

## LOCAL FINANCIAL COMMITMENT

Documentation of a local financial commitment contributes to half of the evaluation and rating of proposed projects. This commitment is demonstrated by:

1. Current financial condition (capital and operating) of the proposed operator of the project;
2. Commitment of capital and operating funds by all local governments and agencies through budget allocations, dedicated tax revenues, and other sources;
3. Reasonableness of assumptions and financial capacity (capital and operating).

Project sponsors who request less than 50% of Section 5309 New Starts share of a total project budget get a bonus of one ranking level higher. Financial commitment must result in a medium rating for the project to move forward in the CIG program.

## PROJECT JUSTIFICATIONS

Utilizing most of FTA's project justification guidelines, an assessment of the individual criteria was performed for the Broad Street Subway Extension using FTA spreadsheet templates to compute the measures, provided in Appendix F. The project justification criteria and sub-factors discussed in this section are shown in Figure 32. More details on each of the criteria and measures can be found in the *Final Interim Policy Guidance* on FTA's website.

This assessment took into consideration the conceptual phase of the BSLX project, with a caveat that further analysis would be required for the project to advance towards detailed design and funding phases, most notably the need to develop and incorporate the current year Build scenarios ridership estimates.

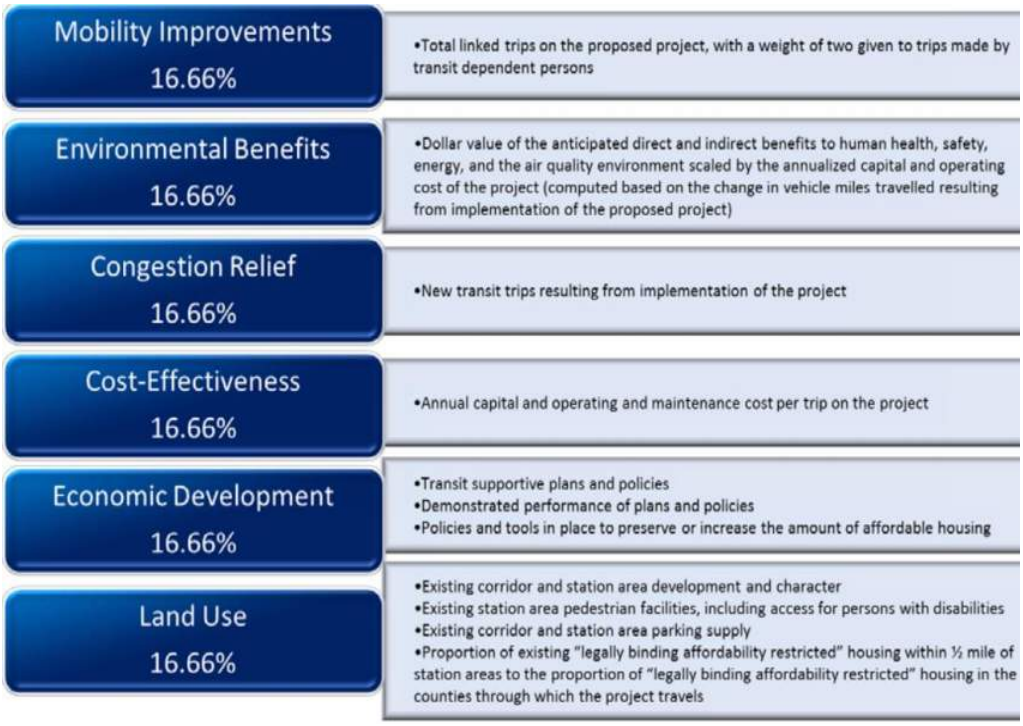



**Figure 32 - New Starts Project Justification Criteria**

## CRITERIA OVERVIEW

The land use measure examines the following elements:

- Existing corridor and station area development;
- Existing corridor and station area development character;
- Existing station area pedestrian facilities, including access for persons with disabilities;
- Existing corridor and station area parking supply; and
- The proportion of existing "legally binding affordability restricted" housing (LBAR) within half a mile of station areas to the proportion of LBAR housing in the counties through which the project travels.

A legally binding affordability restriction is a lien, deed of trust or other legal instrument attached to a property and/or housing structure that restricts the cost of housing units to be affordable to households at specified income levels for a defined period and requires that households at these income levels occupy these units. This definition includes state or federally supported public housing and housing owned by organizations dedicated to providing affordable housing. For the existing affordable housing measure, FTA seeks legally binding affordability restricted units to renters with incomes below 60% of the area median income and/or owners with incomes below the area median that are within ½ mile of station areas.

## BREAKPOINTS

The breakpoints for station area population, employment density, and CBD parking are shown in Table 18.

**Table 18 - Station Area Development and Parking Supply Breakpoints**

| | Station Area Development | | Parking Supply | |
|---|---|---|---|---|
| **Rating** | Employment served by system[1] | Avg. Population density (persons/square mile)[2] | CBD typical cost per day[3] | CBD spaces per employee[4] |
| High | > 220,000 | > 15,000 | > $16 | < 0.2 |
| Medium-High | 140,000-219,999 | 9,600 - 15,000 | $12 - $16 | 0.2 – 0.3 |
| Medium | 70,000-139,999 | 5,760 – 9,599 | $8 - $12 | 0.3 – 0.4 |
| Medium-Low | 40,000-69,999 | 2,561 – 5,759 | $4 - $8 | 0.4 – 0.5 |
| Low | <40,000 | < 2,560 | < $4 | > 0.5 |

[1] The employment breakpoints are based on the Institute for Transportation Engineer's "Toolbox for Alleviating Traffic Congestion," which suggests minimum non-residential development concentrations of 20 million square feet for frequent local bus service and 35 million square feet for light rail service. At 500 square feet per employee, these figures are equivalent to 40,000 and 70,000 employees, respectively. The total employment served includes employment along the entire line on which a no-transfer ride from the proposed project's stations can be reached.
[2] The average population density breakpoints are based on the Institute for Transportation Engineer's "Toolbox for Alleviating Traffic Congestion," which suggests light rail and frequent bus service requires a minimum of 9 to 15 dwelling units per acre. This data has been used to inform the medium breakpoint shown.
[3] CBD core (not fringe parking).
[4] Average across CBD.

The breakpoints for the proportion of legally binding affordability restricted housing (LBAR) in the corridor compared to its proportion in the counties through which the project travels are shown in Table 19.

| Rating | LBAR in the project area / LBAR in surrounding counties |
|---|---|
| High | ≥ 2.50 |
| Medium-High | 2.25 – 2.49 |
| Medium | 1.50 - 2.24 |
| Medium-Low | 1.10 - 1.49 |
| Low | < 1.10 |

Table 19 - Legally Binding Affordability Restricted Housing Breakpoints

The analysis compiled in Table 20 indicates that for the Land Use criteria, the BSLX project might receive a **Low** overall rating based on the existing and horizon year conditions. This is largely a function of relatively low population density, unconstrained parking supply, and lack of affordable housing. The last measure, the legally binding affordability restricted housing (LBAR), is described in more detail below.

| Measure | Likely Rating |
|---|---|
| **Station Area Development: Employment served by system** | **Medium-High.** References employees within ½ mile of every BSL station (assuming 70,000 or more existing employees within ½ of the City Hall station. 2040 projections show 28,000+ jobs within The Navy Yard as well). |
| **Station Area Development: Average Population density (persons/square mile)** | **Low**. There is no residential population within The Navy Yard and minimal population within ½ mile of NRG Station. 2040 projections envision over 1,600 residents in The Navy Yard. |
| **Parking Supply: CBD typical cost per day** | **Low.** Average parking rates in the CBD vary between $12 to $33 daily with an average of $22 - falling into the high rating. But within The Navy Yard itself, all parking is free (surface lots, structures, and on-street parking). |
| **Parking Supply: CBD spaces per employee** | **Low**. Navy Yard parking supply amounts to 0.7 parking spaces per employee (The Navy Yard Master Plan Update of 2013 reports 3.5 parking spaces per 1,000 sq. ft. of office space and PIDC / Liberty Property Trust reports approx. 5 employees per 1,000 sq. ft. of office space). |
| **Legally Binding Affordability Restricted (LBAR) Housing, Corridor's Share compared to Region's Share** | **Low.** There is no existing or planned LBAR housing in The Navy Yard - or in the Stadium District within ½ mile of NRG Station. The share of affordable housing units within the project area would be lower than 110% of the share within the area counties. |

Table 20 - Land Use Rating

The process used to determine the existing share of LBAR housing in the area followed the FTA method and included the following steps, as shown in Figure 33:

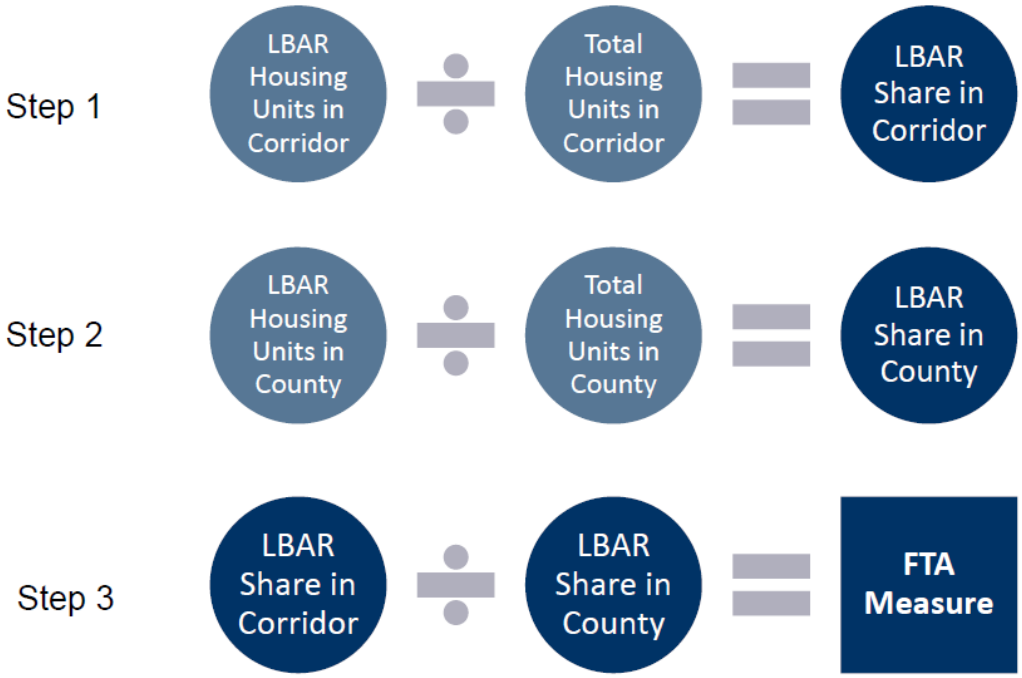



**Figure 33 - Legally Binding Affordability Restricted (LBAR) Housing Justification Criteria Process**

Step 1: Determine LBAR share in the project corridor

a. The National Housing Preservation Database (NHPD) data was used to identify active and inactive Philadelphia County affordable housing units. Both active and inactive search came up with the same number of affordable housing units: 37,355.

**b.** LBAR Housing units in corridor were determined by producing a base GIS map of the corridor, with Census tract, city boundaries, hydrology, and street centerlines layers included. Data from the NHPD and Philadelphia Housing Authority (PHA) were imported into the map which displayed the location of legally binding affordability restricted housing within Philadelphia County. A ½ mile radius was drawn around the NRG Station to capture LBAR housing within that buffer zone. No LBAR housing was captured within half-mile radius of the project corridor.

**LBAR Housing Units in Corridor = 0**

c. The guidance for calculating housing "within corridor" suggests that the number of total housing units and LBAR housing units be calculated on a half-mile radius from stations basis. The estimates below are based on all housing units within the six identified census tracts. Total housing units in the corridor were determined by selecting each census tract that the half-mile buffer touched. The census tracts selected and housing units determined are shown in Table 21.

| Census Tract | Housing Units | Population |
|---|---|---|
| 39.02 | 2,558 | 5,920 |
| 50 | 0 | 0 |
| 372 | 1,856 | 4,354 |
| 373 | 2,517 | 5,093 |
| 9806 | 0 | 0 |
| 9807 | 0 | 0 |
| **Total** | **6,931** | **15,367** |

**Table 21 – Existing Housing Units in the Project Corridor**

Source: US Census Bureau, 2009-2013 5-Year American Community Survey

**Total Housing Units in the Corridor = 6,931**

$$\frac{\boldsymbol{LBAR\ Housing\ Units\ in\ Corridor}}{\boldsymbol{Total\ Housing\ Units\ in\ Six\ Census\ Tracts}} = \boldsymbol{LBAR\ Share\ in\ Six\ Census\ Tracts}$$

$$\frac{\mathbf{0}}{\mathbf{6,931}} = \mathbf{0}$$

Step 2: Determine LBAR Share in the Philadelphia County

a. LBAR housing units in the county were determined by a summation of NHPD housing data. The NHPD data was downloaded and addresses were geocoded to arrive at the number of total LBAR units.

**Total LBAR housing units in county ≈ 37,355**

b. Total housing units in Philadelphia County were determined by 2009-2013 American Community Survey 5- Year estimates.

**Total housing units in county = 668,806**

$$\frac{\boldsymbol{LBAR\ Housing\ Units\ in\ County}}{\boldsymbol{Total\ Housing\ Units\ in\ County}} = \boldsymbol{LBAR\ Share\ in\ County}$$

$$\frac{\mathbf{37,355}}{\mathbf{668,806}} = \mathbf{0.056} = \mathbf{5.6\%}$$

Step 3: Determine FTA Measure

$$\frac{\boldsymbol{LBAR\ Share\ in\ Six\ Census\ Tracts}}{\boldsymbol{LBAR\ Share\ in\ County}} = \boldsymbol{FTA\ Measure}$$

$$\frac{\mathbf{0}}{\mathbf{0.056}\ [\mathbf{5.6\%}]} = \mathbf{0.00}$$

A ratio of less than 1.10 receives a "Low" rating on FTA's

To achieve a 1.50 ratio that would qualify for a "Medium" rating, the percentage of LBAR in the six Census tracts including and surrounding The Navy Yard would need to be 8.4%, or **582 LBAR housing units** (8.4% of the 6,931 total housing units located within the six Census tracts).

Although currently there are no actual housing units within The Navy Yard at all (LBAR or market rate), the Master Plan Update calls for construction of 1,000 housing units to provide housing for 3,000 future residents. The instructions in FTA New Starts guidance indicate that it is acceptable to *visually* estimate the proportion of housing within a one-half mile radius of the proposed stations. The estimate used in the calculations below considers all those potential new housing units in The Navy Yard to determine the LBAR share that would qualify for a "Medium" rating. The Land Use FTA measure is based upon existing housing (total and LBAR), so for this criterion to be attained, certain number of housing units would need to be certified as affordable prior to submission of a New Starts application.

$$\frac{\boldsymbol{Actual}\ LBAR\ Housing\ Units\ in\ Corridor}{Estimated\ Housing\ Units\ in\ Corridor} = Actual\ LBAR\ Share\ in\ Corridor$$

$$\frac{0}{1{,}000} = 0$$

$$\frac{LBAR\ Housing\ Units\ in\ County}{Total\ Housing\ Units\ in\ County} = LBAR\ Share\ in\ County$$

$$\frac{37{,}355}{668{,}806} = 0.056 = 5.6\%$$

$$\frac{Minimum\ Required\ LBAR\ Share\ in\ Corridor}{LBAR\ Share\ in\ County} = FTA\ "Medium"\ Measure$$

$$\frac{0.084\ [8.4\%]}{0.056\ [5.6\%]} = 1.50$$

$$\frac{\boldsymbol{Required\ LBAR\ Housing\ Units\ in\ Corridor}}{\boldsymbol{Estimated\ Housing\ Units\ in\ \ Corridor}} = \boldsymbol{Required\ LBAR\ Share\ in\ Corridor}$$

$$\frac{\mathbf{84}}{\mathbf{1,500}} = \mathbf{8.4}\%$$

To achieve a 1.50 ratio that would qualify for a "**Medium**" rating, the % of LBAR within ½ mile radii of potential Navy Yard station(s) would need to be 8.4%, or **84 LBAR housing units** (8.4% of the 1,000 total housing units expected in The Navy Yard).

Notably, one of the seven sub-criteria for the Economic Development category discussed below is related to tools to maintain or increase the share of affordable housing and with policies committed to at the time of application, it is likely that the BSLX would achieve a **Medium** or higher ranking.

## ECONOMIC DEVELOPMENT

### CRITERIA OVERVIEW

The measure of economic development potential is the extent to which BSLX would likely induce additional, transit-supportive development in the future based on a qualitative examination of the existing local plans and policies to support economic development proximate to the project.

### BREAKPOINTS

This analysis is largely qualitative and relies on review of relevant transit supportive plans and policies, the performance of those plans and policies, and the policies and tools in place to encourage changes in development patterns around the transit investment and the resulting magnitude of changes in population and employment. The measures used in evaluating the plans and policies in place include growth management, transit-supportive policies (including appropriate zoning), availability of tools to implement changes benefiting transit as well as maintain and increase affordable housing, and potential impacts of the proposed project on regional development.[5]

[5] More detailed information regarding the economic development ratings is contained in *the Guidelines for Land Use and Economic Development Effects for New and Small Starts Projects* on FTA website.

## LIKELY RATING

Economic Development rankings shown in Table 22 show an overall likely **Medium** rating for the BSLX project.

| Measure | Likely Rating |
|---|---|
| **Growth Management** | **Medium**.<br>Some land conservation, smart growth, urban- and village-core supportive policies are in place in the region (though largely voluntary in nature, not binding on individual municipalities). Existing market trends tend to favor multi-family, mixed-use, and higher-density developments compatible with transit in urban and town core areas. |
| **Transit-Supportive Corridor Policies** | **Medium.**<br>All potential station area locations are within an area zoned CMX-3 (Community Commercial Mixed-Use), permitting household living, commercial offices, professional services, retail, groceries, convenience stores, sit-down restaurants, educational facilities, government offices, and visitor accommodations. **Medium** criterion suggests that "development patterns proposed in conceptual plans for station areas are at least moderately supportive of a major transit investment." (A **High** rating would require "strongly supportive of a major transit investment" – the availability of large numbers of free parking spaces throughout The Navy Yard would make it difficult to obtain a higher rating.) |
| **Supportive Zoning Near Transit Stations** | **Medium.**<br>CMX-3 Zoning in all potential station areas. "A 'medium' rating can be assigned if existing zoning in most or all transit station areas is already moderately transit supportive." With targeted buildout of approximately 24,000 jobs in core Navy Yard districts (Central Green, Historic, Canal, and Muslin) the job density (of about 40,000 / mile$^2$) will be comparable to downtown Miami (Center City Philadelphia is about three times as high). |
| **Tools to Implement Transit-Supportive Plans and Policies** | **High**.<br>Based upon evidence of transit and regional agencies "working proactively with local jurisdictions, developers, and the public to promote transit-supportive planning and station area development." |
| **Performance of Transit-Supportive Plans and Policies** | **Medium.**<br>Rating in line with criteria description: "Station locations have not been established with finality. Moderate amounts of transit-supportive housing and employment development have occurred in other, existing transit corridors and station areas in the region." Some examples from the region, near SEPTA Regional Rail stations in Lansdale and at Temple University, but no region-wide commitment to TOD. |
| **Potential Impact of Transit Project on Regional Development** | **High**.<br>Rating in line with criteria description: "A significant amount of land in station areas is available for new development or redevelopment at |

| Measure | Likely Rating |
|---|---|
| | transit-supportive densities. Local plans, policies, and development programs, as well as real estate market conditions, strongly support such development." The Navy Yard Master Plan, while supportive of large-scale development in the area, contains little residential (with no commitment to affordable housing) and large amounts of free parking, two elements that are inconsistent with TOD. |
| **Tools to Maintain or Increase Share of Affordable Housing** | **Low.**<br>No affordable housing exists or is planned for the project area. |

**Table 22 - Economic Development Rating**

## COST-EFFECTIVENESS

### CRITERIA OVERVIEW

The 2015 Fixing America's Surface Transportation Act (FAST) requires that the cost-effectiveness criterion for New Starts projects be based on a cost per trip measure. For New Starts projects, the cost-effectiveness measure is computed as the annualized capital cost plus annual O&M cost of the project divided by the annual number of forecasted trips on the project. The number of trips on the project is not an incremental measure – rather, it is the total number of estimated project induced trips. The resulting measure is an annualized cost to provide a linked trip on the project.

### BREAKPOINTS

FTA examined data from projects currently in the New Starts process and developed the breakpoints below based on that information. FTA based the proposed New Starts breakpoints in Table 12 on data contained on average annual capital and operating costs per trip of various modes in the National Transit Database (NTD).

The following data was used to compute the cost effectiveness measure:

- Horizon year 2040 Build daily linked trips ridership forecasts for total trips on the project from the DVRPC travel demand model (including both non-transit dependent and transit dependent persons, based on household income level, below $35,000 annually).
- Current year 2018 minimum ridership estimates that would be required to obtain an overall weighted medium rating for the horizon and current year in the cost-effectiveness category (calculated by taking the average of: (minimum current year ridership estimates + horizon year DVRPC forecasts) / 2).
- Annualization factor (255 weekdays, 52 Saturdays, and 58 Sundays).
- Annualized project capital costs (in current year 2018 dollars). Capital costs were annualized using FTA Standard Cost Categories.
- Annual project O&M costs (in current year 2018 dollars).

The cost-effectiveness measure is then computed as the annualized capital cost plus annual O&M cost of the scenario divided by the annual number of forecasted trips on the project. FTA provides guidance regarding the breakpoints for cost effectiveness criteria, as shown in Table 23.

| Rating | Range |
|---|---|
| High | < $4.00 |
| Medium-High | Between $4.00 and $5.99 |
| **Medium** | **Between $6.00 and $9.99** |
| Medium-Low | Between $10.00 and $14.99 |
| Low | > $15.00 |

**Table 23 – Cost-Effectiveness Breakpoints**

The annualized capital and annual operating costs for the three Build heavy rail scenarios are provided in current year dollars in Table 24. The total annualized cost was used to estimate both the 2040 Build horizon year and 2018 current year costs per trip.

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| Annualized Capital Cost | $22,121,014 | $40,192,260 | $42,720,343 |
| Annual O&M Cost | $2,176,570 | $3,431,898 | $3,728,360 |
| **Total Capital and O&M Costs** | **$24,297,584** | **$43,624,158** | **$46,448,703** |

**Table 24 – BSLX Annualized Capital and O&M Costs in Constant 2018 $s**

## LIKELY FUTURE YEAR RATING

The cost per trip was computed by dividing the annual cost by annual forecasted trips provided by DVRPC. The cost per trip for the future year forecasts are provided in Table 25. Alternative 1 would receive the highest, **Medium** rating ($6.11/trip) using FTA breakpoints and future year (2040) forecasts. Alternatives 2 and 3 would likely receive a **Medium-Low** rating.

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| Daily Project Trips | 10,900 | 11,400 | 10,900 |
| Annual Project Trips | 3,978,500 | 4,161,000 | 4,015,000 |
| ***Cost Per Project Trip*** | ***$6.11*** | ***$10.48*** | ***$11.57*** |
| **2040 Build Likely Rating** | **Medium** | **Medium-Low** | **Medium-Low** |

**Table 25 – BSLX Horizon Year 2040 Cost-Effectiveness Rating**

## CURRENT YEAR RATING OBJECTIVE

Using only the horizon year 2040 forecasts, one of the BSL extension alternatives would receive a **Medium** rating in the cost-effectiveness category. However, the new FTA guidelines require that the current year and horizon year 2040 forecasts be equally weighted when sponsors elect to perform horizon year forecasts [(current + horizon year) / 2].

**Current year ridership forecasts were not available for this study. The following table presents the minimum ridership needed to achieve an overall weighted Medium rating for cost-effectiveness for each alternative (shown in Table 26).**

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| **Assumed Daily Project Trips** | **4,800*** | **12,600*** | **15,350*** |
| **Assumed** Annual Project Trips | 1,752,000 | 4,599,000 | 5,602,750 |
| **Assumed *Cost Per Project Trip*** | ***$13.87*** | ***$9.49*** | ***$8.29*** |
| **2018 Build Rating Objective** | **Medium-Low** | **Medium** | **Medium** |

**Table 26 – BSLX Current Year 2018 Cost-Effectiveness Rating (Assumed Minimum Ridership)**

*Minimum daily ridership estimate needed to obtain weighted medium cost-effectiveness rating

## WEIGHTED RATING OBJECTIVE

The equally weighted results shown in Table 27 display **Medium** ratings for all three scenarios, below the $10 cost per trip rating threshold. **The ridership assumptions for the current year presented above are the absolute minimum necessary to achieve a weighted Medium rating objective**. To further assess the viability of this project advancing for federal funding, the current year Daily Project Trips ridership forecast needs to be developed by DVRPC.

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| Daily Project Trips | 7,850 | 12,000 | 13,125 |
| Annual Project Trips | 2,865,250 | 4,380,000 | 4,790,625 |
| ***Cost Per Project Trip*** | ***$9.99*** | ***$9.99*** | ***$9.93*** |
| **Weighted Rating Objective** | **Medium** | **Medium** | **Medium** |

**Table 27 – BSLX Weighted Cost-Effectiveness Rating (Assumed Ridership)**

## CRITERIA OVERVIEW

FTA evaluates mobility improvements for New Starts projects as the total number of linked trips using the proposed project, with a weight of two given to trips that would be made on the project by transit dependent persons. Linked trips using the proposed project include all trips made on the project if the rider boards or alights on the project or elsewhere in the transit system.

## BREAKPOINTS

The following data was entered in the templates to compute the mobility improvements measure:

- Horizon year 2040 Build daily linked trips ridership forecasts from the DVRPC travel demand model for non-transit dependent and transit dependent persons (based on household income level, below $35,000 annually).
- Current year 2018 minimum ridership estimates that would be required to obtain an overall weighted medium rating for the horizon and current year in the mobility category (calculated by taking the average of: (minimum current year ridership estimates + horizon year DVRPC forecasts) / 2).
- Annualization factor (255 weekdays, 52 Saturdays, and 58 Sundays).

The mobility improvements measure is computed by adding the estimated number of linked transit trips on the project taken by non-transit dependent persons and the number of linked transit trips taken by transit dependent persons multiplied by a factor of two, thus assigning extra weight to those trips. FTA provides guidance regarding the breakpoints for mobility criteria, as shown in Table 28.

| Rating | Mobility Improvements: Estimated Annual Trips* |
|---|---|
| High | > 30 Million |
| Medium-High | 15 Million – 29.9 Million |
| **Medium** | **5 Million – 14.9 Million** |
| Medium-Low | 2.5 Million – 4.9 Million |
| Low | < 2.5 Million |

**Table 28 – Mobility Breakpoints**

* Trips by non-transit dependent persons plus trips by transit dependent persons multiplied by two

## LIKELY FUTURE YEAR RATING

Daily 2040 Build horizon year non-transit dependent and transit dependent ridership for the three rail scenarios is provided in Table 29. All three scenarios would likely receive a **Medium** rating using FTA breakpoints and future year (2040) ridership forecasts, with Alternative 2 performing slightly better than the others.

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| Daily Project Trips by Non-Transit Dependents | 4,600 | 4,900 | 4,700 |
| Daily Project Trips by Transit Dependents | 6,200 | 6,500 | 6,300 |
| Daily Project Trips | 17,000 | 17,900 | 17,300 |
| Annual Project Trips | 6,205,000 | 6,533,500 | 6,314,500 |
| **2040 Build Likely Rating** | **Medium** | **Medium** | **Medium** |

**Table 29 – BSLX Horizon Year 2040 Mobility Rating**

## CURRENT YEAR RATING OBJECTIVE

Using only the horizon year 2040 forecasts, all three BSL extension alternatives would likely receive a medium rating in the mobility category. However, like the cost-effectiveness criteria, FTA guidelines require that the current year and horizon year 2040 forecasts be equally weighted when sponsors elect to perform horizon year forecasts for the mobility criteria [(current + horizon year) / 2].

**The current year ridership assumptions are the absolute ridership minimums that would be required to achieve an overall weighted Medium mobility rating (the average of current year and horizon year ratings).** The current year mobility measure is provided in Table 30. In order to further assess the viability of this project advancing for federal funding, the current year Daily Project Trips ridership forecast needs to be developed by DVRPC.

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| **Assumed** Daily Project Trips by Non-Transit Dependents | 2,800* | 2,600* | 2,700* |
| **Assumed** Daily Project Trips by Transit Dependents | 3,800* | 3,500* | 3,700* |
| **Assumed** Daily Project Trips | 10,400 | 9,600 | 10,100 |
| **Assumed** Annual Project Trips | 3,796,000 | 3,504,000 | 3,686,500 |
| **2018 Build Rating Objective** | **Medium-Low** | **Medium-Low** | **Medium-Low** |

**Table 30 – BSLX Current Year 2018 Mobility Rating (Assumed Minimum Ridership)**

*Minimum daily ridership estimate needed to obtain weighted medium mobility rating

### WEIGHTED RATING OBJECTIVE

The equally weighted results shown in Table 31 display **Medium** ratings for the three scenarios, above the 5 million annual trips criteria threshold. The ridership assumptions presented above are the absolute minimum necessary to achieve a weighted Medium rating objective. In order to further assess the viability of this project advancing for federal funding, the Daily Project Trips ridership forecast needs to be developed by DVRPC.

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| Daily Project Trips by Non-Transit Dependents | 3,700 | 3,750 | 3,700 |
| Daily Project Trips by Transit Dependents | 5,000 | 5,000 | 5,000 |
| Daily Project Trips | 13,700 | 13,750 | 13,700 |
| Annual Project Trips | 5,000,500 | 5,018,750 | 5,000,500 |
| **Weighted Rating Objective** | **Medium** | **Medium** | **Medium** |

**Table 31 – BSLX Weighted Mobility Rating (Assumed Ridership)**

## CONGESTION RELIEF

### CRITERIA OVERVIEW

FTA evaluates congestion relief based on the number of new weekday linked transit trips resulting from implementation of the proposed project. Although it is an indirect measure of roadway congestion relief due to implementation of a transit project, it serves as an indicator of potential modal shift and motor vehicles taken off the road.

### BREAKPOINTS

The following data was used to compute the congestion relief measure:

- Details on existing and proposed operations (timetables, peak hour, peak direction, peak fleet)
- Change in ridership forecasts between the Build scenarios and No Build and Build alternatives = the number of new linked weekday trips generated by the project

Since the measure of new weekday linked transit trips is an incremental value, a basis for comparison was required: the proposed project's Build scenarios were compared to the No Build scenario. New weekday linked transit trips are calculated by comparing total weekday linked transit trips for the No Build scenario with total weekday linked transit trips for the Build scenarios. FTA provides guidance regarding the breakpoints for congestion relief criteria, as shown in Table 32.

| Rating | Range of New Weekday Linked Transit Trips |
|---|---|
| High | 18,000 and above |
| Medium-High | Between 10,000 to 17,999 |
| **Medium** | **Between 2,500 and 9,999** |
| Medium-Low | Between 500 and 2,499 |
| Low | 499 or less |

**Table 32 – Congestion Relief Breakpoints**

## LIKELY FUTURE YEAR RATING

Daily 2040 Build horizon year new linked weekday ridership for the three rail scenarios is provided in Table 33. All three scenarios would likely receive a **Medium** rating using FTA breakpoints and future year (2040) ridership forecasts, with Alternative 2 performing slightly better than the others.

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| New Linked Weekday Project Trips | 4,600 | 5,100 | 4,600 |
| Annual New Linked Weekday Project Trips | 1,173,000 | 1,300,500 | 1,173,000 |
| **2040 Build Likely Rating** | **Medium** | **Medium** | **Medium** |

**Table 33 – BSLX Horizon Year 2040 Congestion Relief Rating**

## CURRENT YEAR RATING OBJECTIVE

Using only the horizon year 2040 forecasts, all three BSL extension alternatives would likely receive a medium rating in the congestion relief category. However, like the above criteria, FTA guidelines require that the current year and horizon year 2040 forecasts be equally weighted when sponsors elect to perform horizon year forecasts for the congestion relief criteria [(current + horizon year) / 2].

**The current year ridership assumptions are the absolute new trip ridership minimums that would be required to achieve an overall weighted Medium congestion relief rating (the average of current year and horizon year ratings).** The current year congestion relief measure is provided in Table 34. In order to further assess the viability of this project advancing for federal funding, the New Weekday Project Trips ridership forecast need to be developed by DVRPC.

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| **Assumed** New Linked Weekday Project Trips | 400 | 0 | 400 |
| **Assumed** Annual New Linked Weekday Project Trips | 102,000 | 0 | 102,000 |
| **2018 Build Rating Objective** | **Medium-Low** | **Medium-Low** | **Medium-Low** |

**Table 34 – BSLX Current Year 2018 Congestion Relief Rating (Assumed Minimum Ridership)**

*Minimum new weekday linked trips needed to obtain weighted medium congestion relief rating

### WEIGHTED RATING OBJECTIVE

The equally weighted results shown in Table 35 display **Medium** ratings for the three scenarios, at or above the 2,500 newly generated linked project trips criteria threshold. The ridership assumptions presented above are the absolute minimum necessary to achieve a weighted Medium rating objective. In order to further assess the viability of this project advancing for federal funding, the New Weekday Linked Project Trips forecast needs to be developed by DVRPC.

| | 1: Rouse Blvd | 2: 13th St and Constitution Ave | 3: Broad St and Kitty Hawk Ave |
|---|---|---|---|
| New Linked Weekday Project Trips | 2,500 | 2,550 | 2,500 |
| Annual New Linked Weekday Project Trips | 637,500 | 650,250 | 637,500 |
| **Weighted Rating Objective** | **Medium** | **Medium** | **Medium** |

**Table 35 – BSLX Weighted Congestion Relief Rating (Assumed Ridership)**

## ENVIRONMENTAL BENEFITS

### CRITERIA OVERVIEW

FTA evaluates and rates the environmental benefits criterion for New Starts projects based upon the dollar value of the anticipated direct and indirect benefits to human health, safety, energy, and the air quality environment scaled by the annualized capital and O&M costs of the project. These benefits are computed based on the change in vehicle miles traveled (VMT) resulting from implementation of the proposed project.

### BREAKPOINTS

Environmental benefits can include the following sub-factors: change in air quality criteria pollutants, change in energy use, change in greenhouse gas emissions, and change in safety. Using the percent change

in VMT as a sole input, the estimated environmental benefits of the project were monetized and compared to the same annualized capital and operating costs used in the cost-effectiveness calculation. Since change in VMT is an incremental measure, a point of comparison was used to calculate the environmental benefits: the 2040 Build scenarios were compared to the 2040 No Build scenario.

The environmental benefits measure is the sum of the monetized value of the benefits resulting from the changes in air quality and greenhouse gas emissions, energy use, and safety divided by the annualized capital and operating cost of the project (as used in the cost effectiveness measure). The resulting ratio is multiplied by 100 and shown as a percentage. FTA provides guidance regarding the breakpoints for environmental benefits criteria, as shown in Table 36.

| Rating | Range |
|---|---|
| High | > 10% |
| Medium-High | 5 to 10% |
| **Medium** | **0 to 5%** |
| Low-Medium | 0 to -10% |
| Low | < -10% |

**Table 36 – Environmental Benefits Breakpoints**

### LIKELY RATING

Table 37 summarizes the overall likely current year 2018 Build and horizon year 2040 environmental benefits for the three rails scenarios developed by populating FTA's New Starts 'Environmental Benefits' templates. The New Starts templates include all the conversion factors necessary to calculate changes in air quality, energy use, greenhouse gas emissions, and safety resulting from the changes in highway and transit VMT.

The environmental benefits rating is automatically calculated in the templates based on a weighted average that gives 50% weight to the current year and 50% weight to the horizon year benefits and required input of just the following measures: (1) change in VMT, and (2) annualized capital and O&M costs. As shown in Table 26, all three scenarios would likely receive above a **Medium** rating using FTA breakpoints from Table 25, with Alternative 2 potentially qualifying for the **High** rating in this category.

| | 1: Rouse Blvd | | 2: 13th St and Constitution Ave | | 3: Broad St and Kitty Hawk Ave | |
|---|---|---|---|---|---|---|
| | **2018 Build** | **2040 Build** | **2018 Build** | **2040 Build** | **2018 Build** | **2040 Build** |
| Value of Environmental Benefits | $2,276,275 | $2,522,610 | $2,912,821 | $7,146,948 | $1,935,193 | $4,748,225 |
| Annualized Capital and O&M Cost | $24,297,584 | $24,297,584 | $43,624,158 | $43,624,158 | $46,448,703 | $46,448,703 |
| Ratio of Environmental Benefits to Annualized Cost | 9.4% | 10.4% | 6.7%% | 16.4% | 4.2% | 10.2% |
| Value Used in Rating | 9.9% | | 11.5% | | 7.2% | |
| **Weighted Rating Objective** | **Medium-High** | | **High** | | **Medium-High** | |

**Table 37 – BSLX Current Year 2018 and Horizon Year 2040 Environmental Benefits Rating (Assumed Ridership)**

#### FINANCIAL COMMITMENT

The New Starts projects' applicants need to show an acceptable degree of local financial commitment, including evidence of stable and dependable financing sources to construct, maintain and operate the extension, and maintain and operate the rest of the transit network without a reduction in existing services. Project sponsors are required to prepare a financial plan and 20-year cash flow statement for the proposed project.

For the Phase 2 Feasibility Study, it is assumed that SEPTA could meet a medium rating for the financial commitments. SEPTA, as well as the Philadelphia metropolitan area, would need to weigh the need for this project against other considered projects in the region.

## SUMMARY OF PRELIMINARY EVALUATION ANALYSIS

This preliminary 'mock' New Starts analysis shows that the BSLX project would likely perform sufficiently well and obtain at least a **Medium** overall weighted rating in the congestion relief, environmental benefits, and economic development project justification criteria. Ultimately though, to obtain a favorable rating qualifying this project for potential entry into the New Starts program, most of the following qualifiers would need to be met:

- **Cost-Effectiveness**: based on the available future year 2040 ridership forecasts Alternative 1 would likely receive a Medium rating, while Alternatives 2 and 3 would likely receive a Medium-Low. Current year ridership is needed to properly determine the cost-effectiveness rating for the

project. Minimum current year Build scenario ridership required to achieve an overall weighted Medium rating in the cost-effectiveness category was calculated (4,800 Daily Project Trips in Alternative 1 to 15,350 in Alternative 3). The current year ridership forecast would need to be confirmed in the regional travel demand model.

- **Mobility**: similar to the above criteria, minimum current year Build scenario ridership levels with Daily Trips broken down by captive vs. choice transit riders would need to be confirmed in the TIM. These ridership outputs would need to be in the 2,600 to 2,800 Daily Trips range for non-transit dependent riders and 3,500 to 3,800 Daily Trips for transit dependent riders.
- **Land Use**: all three scenarios would likely to receive a low rating in this category, a function of relatively low population density, lack of affordable housing, and unconstrained parking supply. Steps could be taken to mitigate this issue and increase the rating by, for instance, reducing the parking supply and/or charging parking fees, and proposing development of more residential units (currently none exist in The Navy Yard), including zoning for affordable housing. Provision of affordable housing in the project area would likely further increase the economic development rating as well.
- **Local Financial Commitment:** for the purposes of the Phase 2 Feasibility Study, it was assumed that the required share of local funding for the project (at least 50% of the total cost) would be secured, but the reality is BSLX would compete for a very limited pool of transit funding, with no dedicated local funding mechanism that is available to multiple peer transit agencies.

**None of the three scenarios would likely perform well enough to obtain an overall weighted Medium rating based on the data available at the time of the Phase 2 Feasibility Study.**

## 7.4 BUS ALTERNATIVES FEASIBILITY SCREENING

### FEASIBILITY SCREENING OVERVIEW

The 2040 horizon year ridership and traffic volumes output from the DVRPC travel forecasting model and capital and O&M cost estimates for the identified potential alignments served as inputs to assess feasibility and make some determinations on whether the subway Alternatives 1 through 3 might be eligible for FTA New Starts program funding. Since the bus only Alternatives 4 through 6 have minimal capital investment requirements, a different method was needed to compare them. SEPTA's Comparative Evaluation Process was chosen to evaluate the bus scenarios – currently used by the agency to assess whether all service proposals meet minimum service standards and impact SEPTA's Operating Budget. The process compares Alternatives 4, 5, and 6 with respect to their passenger and community benefits, relative to the operating costs. This comparison will indicate which proposals return the greatest overall benefit for each dollar spent.

In a similar approach to the 'mock' New Starts project readiness high-level screening performed for the heavy rail scenarios, the Comparative Evaluation Process also investigated the bus scenarios' cost-effectiveness to increase transit accessibility, potential to improve area mobility, increase transit ridership, fair distribution of transit services, and support opportunities for economic development. The

findings might inform future planning tasks that would be completed to improve transit access to The Navy Yard.

## COMPARATIVE EVALUATION PROCESS

The Comparative Evaluation Process is used by SEPTA for service proposals that meet minimum service standards and impact the agency's Operating Budget. The high-level evaluation of the bus scenarios consisted of the following elements, described in more detail below:

1. Cost analysis (O&M cost minus farebox revenue)
2. Community benefit analysis

### COST ANALYSIS

Cost analysis is a service enhancement evaluation tool used by SEPTA that is similar to the New Starts' Cost-Effectiveness criteria in that it is based on the estimated annualized project cost (on a per trip basis). SEPTA's criteria focus is on the O&M costs (rather than a combination of O&M and capital costs), a more fitting approach for the bus projects that include negligible capital investment. Table 38 details costing situations SEPTA factors in when utilizing the fully allocated or incremental peak costs related to establishment of new route or bus service or modification of existing routes.

In terms of the three potential bus enhancement options, the summary ridership forecasts for the horizon year 2040 and implications on the incremental peak O&M costs, in current year 2018 dollars, are shown in Table 39. Annualized costs adhere to SEPTA's three key supply variables: vehicle-hours, vehicle-miles, and the number of peak vehicles. The underlying assumption behind the allocation model is that the cost of supplying a transit service is directly related to the number of vehicle hours of service provided, the number of miles traveled, and the number of needed vehicles in service.

Based on this service model, the annual incremental O&M costs, shown in Table 39, range from $1.2 million for Alternative 6 and $1.5 million annual bus service costs for Alternative 4, but are much higher for Alternative 5, with $2.9 million needed to fund the expanded Loop and Express bus network.

The proposed enhancements add anywhere from 49,000 annual miles and 18,500 annual hours for Alternative 4, and 162,000 annual miles for Alternatives 5 and 6. The proposed discontinuance of Express shuttle service is excluded from the total O&M costs since increased service on the Loop shuttle (scenario 4) and modified and extended Route 45 service provision (scenario 6) provide substitute service. The effects on peak vehicle (PV) requirements range from three additional PVs estimated to be needed for Alternatives 4 and 6 and five PVs for Alternative 5. The passenger revenue in this model is negligible as the scenarios assume - for this analysis - that most of the analyzed bus services will remain fare-free (i.e., Loop and Express shuttles), with only Route 45 assigned an average fare to each new forecasted passenger trip.

| | Vehicle Hours | Vehicle Miles | Fully Allocated Peak | Incremental Peak |
|---|---|---|---|---|
| **Establishment of New Route/Service:** | | | | |
| Adds Peak Vehicles | X | X | N/A | X |
| No Additional Peak Vehicles | X | X | N/A | N/A |
| **Modification of Existing Routes/ Services:** | | | | |
| Adds Peak Vehicles | X | X | N/A | X |
| Decreases Peak Vehicles | X | X | N/A | X |
| Additional Service – No Impact on Peak Vehicles | X | X | N/A | N/A |
| Decreased Service -- No Impact on Peak Vehicles | X | X | N/A | N/A |

Table 38 – SEPTA's Comparative Evaluation Process Elements

| Scenario | Mode | Average Passenger Fare | New Linked Trips | Operator $ per V-hour | Vehicle hours | O&M per V-mile | Vehicle miles | Overhead - per peak vehicle | Incremental peak vehicle | Fairbox Revenue | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alt. 4** | Loop East & West | N/A | 2,600 | $63.99 | 18,478 | $3.40 | 49,275 | $47,000 | 3 | N/A | **$1,490,950** |
| **Alt. 5** | Loop East & West | N/A | 2,900 | $63.99 | 18,478 | $3.40 | 49,275 | $47,000 | 3 | N/A | **$1,490,950** |
| | Express | | | $63.99 | 14,454 | $3.40 | 112,420 | $47,000 | 2 | N/A | **$1,401,139** |
| **Alt. 6** | Route 45 | $1.09 | 1,600 | $63.99 | 10,281 | $3.40 | 155,125 | $47,000 | 2 | $444,720 | **$834,576** |
| | Loop West | N/A | | $63.99 | 4,897 | $3.40 | 6,388 | $47,000 | 1 | N/A | **$382,082** |

Table 39 – 2040 Build Bus Scenarios Cost Analysis (2018 $s)

**COMMUNITY BENEFIT ANALYSIS**

SEPTA acknowledges that the annual net change in cost, revenue, ridership and operating ratio are not the only measures to evaluate a given service proposal with budgetary impacts. Consequently, select additional Community Benefit Analysis criteria was used to further evaluate the bus scenarios. Under optimal circumstances, this analysis would include both quantitative and qualitative comparison of ridership increase, late night passenger trips, transfer rate, travel time analysis, and proximity to transit. These categories would be assigned benefits points based on importance scale and benefits would be totaled and divided by the O&M cost to determine a Final Benefit Score (FBS). The passenger benefits by expenditures for each scenario would provide a full-picture comparison of the alternatives. The higher the FBS, the higher the relative community benefit-per-dollar expended for each scenario.

For this analysis, the only available forecasted data for the Community Benefit Analysis was the number of passengers gained and/or lost. Nonetheless, the ridership projections provided enough insight to compare the potential bus scenarios to the No Build scenario, as well as to cross-examine by service efficiency.

The ridership forecast indicate that the 2040 Build bus enhancements could attract a total of:

- 9,200 total passenger trips for Alternative 5 - and 2,900 additional new riders in comparison to the 2040 No Build scenario
- 8,900 total passenger trips for Alternative 4 - and 2,600 additional new riders in comparison to the 2040 No Build scenario
- 7,900 total passenger trips for Alternative 6 - and 1,600 additional new riders in comparison to the 2040 No Build scenario

When converted to annualized benefit points and divided by annual O&M costs, the FBS shows that the most efficient scenario would likely be Alternative 4, despite its slightly lower ridership forecast in comparison to Alternative 5 (see Table 40). Although all three bus scenarios' FBS is higher than the No Build scenario, Alternative 4 that increases the Loop service is a clear recommended candidate for implementation, followed by Alternative 6 that extends Route 45 to The Navy Yard, and Alternative 5 that enhances both the Loop and Express shuttles' service.

The resulting FBSs are a function of cost-effectiveness – although Alternative 5 projections call for the highest number of attracted transit riders, those trips come at a high O&M cost that makes them expensive per rider. The resulting FBS for Alternative 5 is only slightly higher than the FBS for the No Build option.

| Service | Benefit Points | No Build | 4: Loop | 5: Loop & Express | 6: Route 45 & West Loop |
|---|---|---|---|---|---|
| Weekday Ridership | 1.00 | 6,300 | 8,900 | 9,200 | 7,900 |
| Annualized Benefit Points | | 1,606,500 | 2,269,500 | 2,346,000 | 2,014,500 |
| Annual O&M Costs | | $2,319,676 | $1,490,950 | $2,892,089 | $1,661,378 |
| **Final Benefit Score (FBS)** | | **0.69** | **1.52** | **0.81** | **1.21** |

Table 40 – 2040 Bus Alternatives Community Benefit Analysis – Weekday Ridership Benefit Score

## SUMMARY OF PRELIMINARY EVALUATION ANALYSIS

The growth forecast for The Navy Yard is extraordinary: the employment in The Navy Yard is projected to increase from 11,000 to 36,000 in 2040, and planned residential units could provide housing for 3,000 new residents. The existing bus shuttles would not be able to handle the new riders, and providing enough parking for commuters and residents would limit development. The analyzed 2040 Build bus scenarios show their potential to address the expected increased transit demand in The Navy Yard with minor capital investment and at a reasonable O&M cost.

The preliminary Comparative Evaluation Process identified Alternative 4 as the most cost-effective bus scenario that offers the best return on investment in terms of benefits relative to the operating costs. It could be a viable and feasible lower cost option to the potential heavy rail extension of the Broad Street Subway Line to The Navy Yard.

# 8 PUBLIC OUTREACH

The Broad Street Line Extension Phase 2 Feasibility Study utilized a multi-tiered stakeholder and public involvement process throughout the duration of the project to facilitate and gain input from multiple angles to ensure the final alternatives reflected the needs of the local community.

## STAKEHOLDER AND STEERING COMMITTEES

During project initiation, two project committees were established to provide direction at key points during the study. The first committee, entitled the "steering committee", consisted of technical staff in SEPTA, the Delaware Valley Regional Planning Commission (DVRPC), City of Philadelphia Office of Transportation and Utilities (OTIS), the Pennsylvania Industrial Development Corporation (PIDC), and PennDOT. This committee met a total of four times throughout the process and provided critical direction for the project team.

The second committee, entitled the "stakeholder committee", consisted of larger regional stakeholders that have a vested interest in the outcome of the study. This group met three times during the project and provided a user-side perspective of the proposed alternatives. The stakeholder committee included the following representatives:

Navy Yard Management and Development

- Philadelphia Industrial Development Corp.
- Liberty Property Trust
- CBRE Property Management

Public Agencies

- SEPTA
- DVRPC
- Philadelphia City Planning Commission
- PennDOT

Elected Officials

- Office of US Senator Bob Casey
- Office of US Representative Patrick Meehan
- Philadelphia City Council

Labor Organizations

- IBEW Local 98
- LU 692
- Philadelphia Building Trades

Navy Yard Employers

- US Navy
- GlaxoSmithKline
- Urban Outfitters

It is important to note that the last formal stakeholder committee meeting was held in late 2017, and the list above reflects participants in the process at that time.

## PUBLIC ENGAGEMENT

To further encourage an informed study process, a robust public involvement approach was utilized to solicit input from current and future potential users of transit service to the Philadelphia Navy Yard. This was primarily accomplished through online and paper surveys.

The project utilized a MetroQuest survey, a web-based interactive survey created to gain public input and determine commuting patterns for employees in The Navy Yard. The main purpose of the survey was to determine commuting patterns of employees in The Navy Yard in order for DVRPC to validate the travel demand model. In addition, respondents were given the chance to rank the project goals set forth in the Purpose and Need statement. This survey was promoted and administered at tabling events, and postcards with the survey link were distributed to businesses in The Navy Yard. Throughout the online survey tool, nearly 1,300 Navy Yard employees participated, representing a nearly 10% self-selected sample of total employees.

Accompanying the online survey was a paper survey distributed to employees at manufacturing facilities in The Navy Yard that may not have access to a computer in the daily work activities. More than 50 employees participated in the paper survey.

To further advance available information related to the project, a project website, www.bslxnavyyard.com was established at study initiation. The website featured a project description and served as a repository for public documents, including the purpose and need statement and an up-to-date project schedule. The website also included a monitored e-mail inbox for general questions from the public.



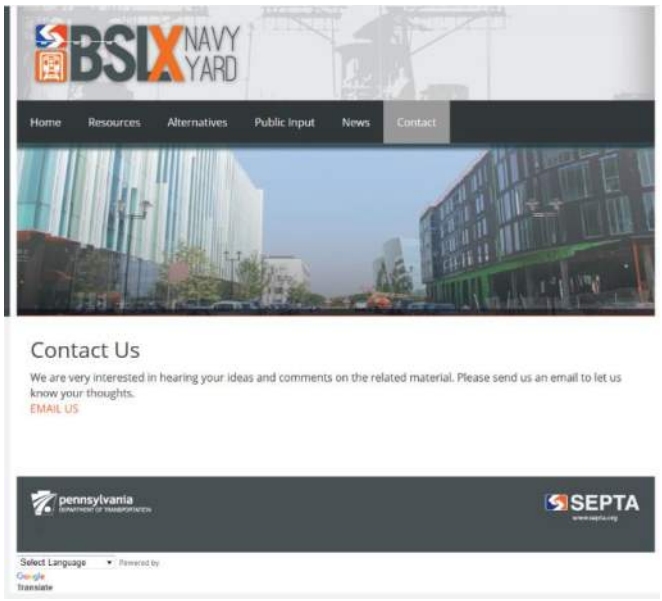



Figure 34 – Broad Street Line Extension Project Website

## DRAFT PLAN RECOMMENDATIONS OUTREACH


On January 31, 2019 a public open house was conducted at Building 101 in the Philadelphia Navy Yard to review the proposed study recommendations. The open house began with an opportunity for stakeholder committee members and public officials to view the proposed recommendations and ask questions, followed by two open sessions. Information about the meeting was posted throughout The Navy Yard and was distributed via email to stakeholder and steering committee members, and to all employers of The Navy Yard.

Information was displayed on a series of information boards with project team members available to present information, answer any questions, and receive comments on the proposed recommendations.

In total, more than 50 individuals participated in the public open house sessions, with may representing large organizations and gathering information on behalf of their colleagues.

Following the public open house, materials were posted to the project website, www.bslxnavyyard.com, to allow for additional participation from individuals who were not able to attend the event. An email address was supplied on the webpage to allow comments to be sent directly to the project team.

Through the open house review process, a number of important comments were received and responded to. A summary of the comments is provided below.

- There were discussions about the impacts of sea level rise and flooding on The Navy Yard, particularly in relation to any future development or expansion of rail service.
- Several participants asked about potential traffic impacts when construction of the BSL is initiated, particularly near the entrance to The Navy Yard on the I-95 on-ramps. It was explained that while a cut and cover method would significantly impact traffic in these areas, using a Tunnel Boring Machine (TBM) would eliminate traffic impacts except for near the staging areas.
- There was interest in maintaining the existing express bus service along with the recommended improvements with bus Alternative 4. This feedback was applied to the final recommendation.

- The potential for implementing light rail service to The Navy Yard was mentioned. It was explained that this was not explored as part of this study.
- In general, multiple participants lauded the current Navy Yard Shuttle and expressed a desire to continue to see it operate, and potentially expand as employment increases
- The need for residential housing units in The Navy Yard was identified by participants, especially as a way to continue making the case for transportation investments

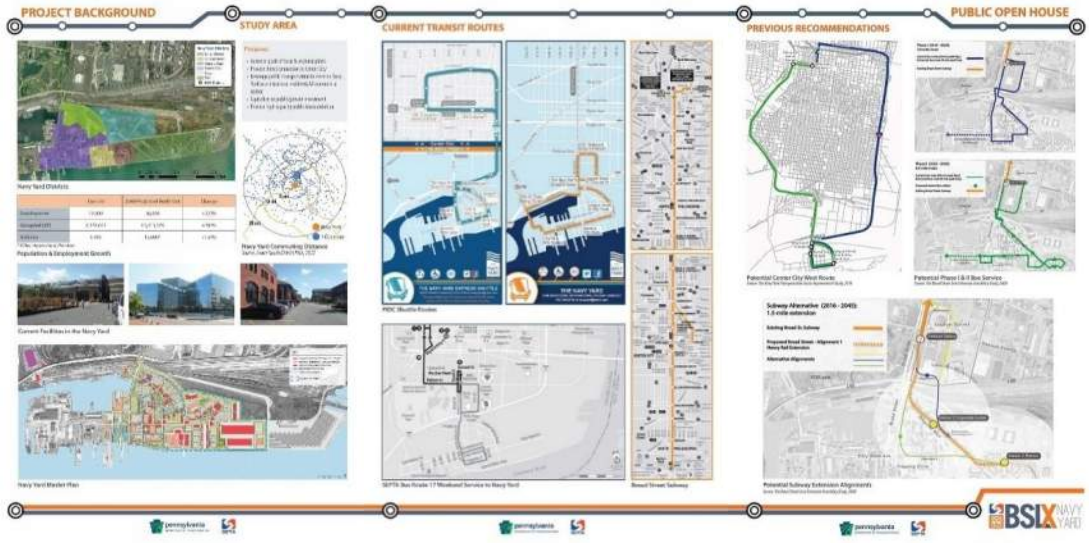
## FUTURE OUTREACH

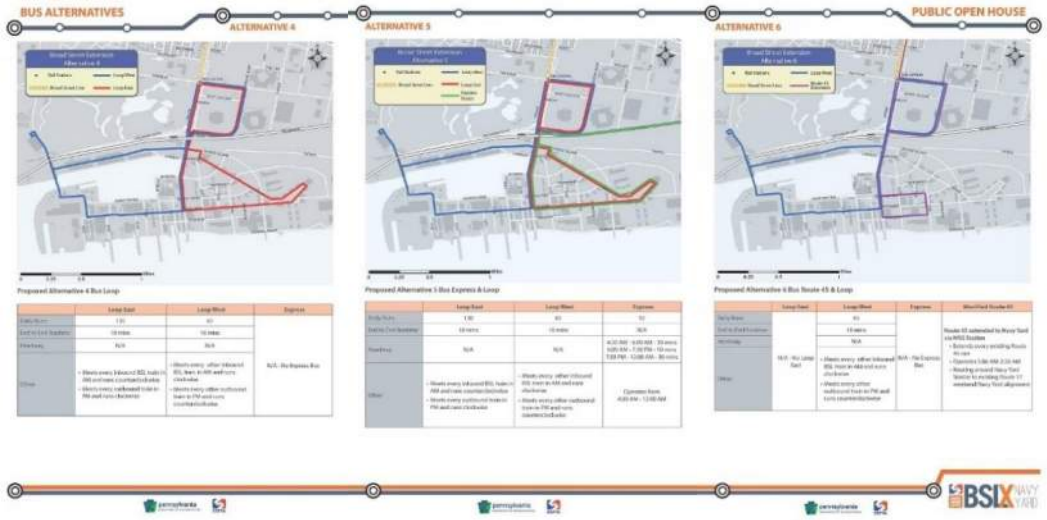
As the study recommendations are implemented, additional public input opportunities will be made available.

As multimodal improvements are contemplated at NRG Station, the local community will be engaged to bring awareness of any planned improvements and to receive input on the most appropriate amenities to be included in any such improvements.

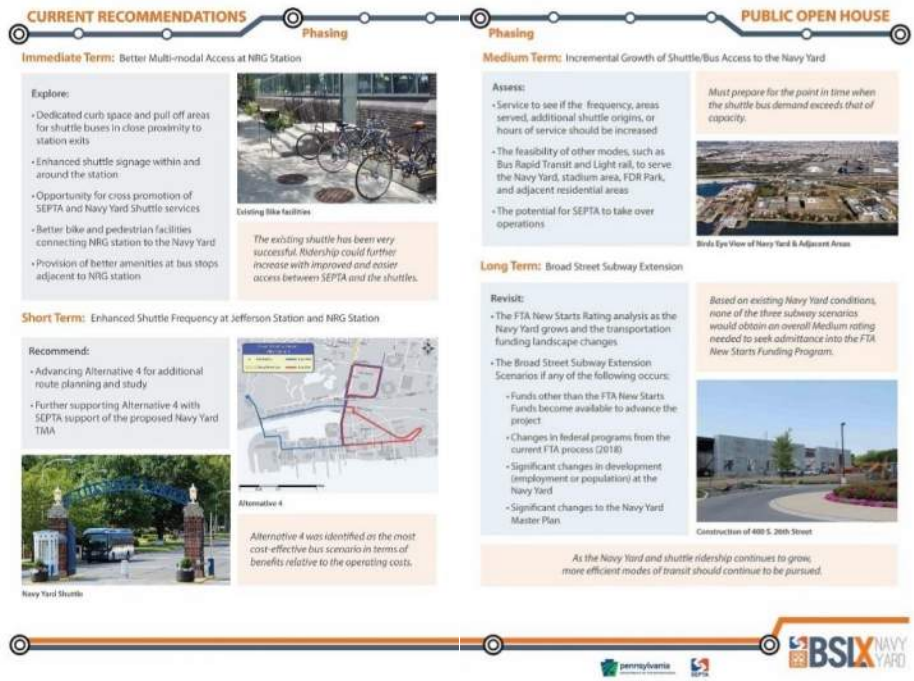
As The Navy Yard continues to expand, additional public transportation options will need to be provided, as identified previously in the report. Changes to The Navy Yard shuttle, or as additional bus routes are introduced, the public must be engaged to identify the best ways in which to implement these changes.

Finally, if the subway or similar major capital investment moves forward, significant public input will be necessary throughout the National Environmental Policy Act (NEPA) and design and engineering process. These public input opportunities will be geared specifically towards the planned improvements at the time, and allow businesses, employees, and local community members an opportunity to review progress and respond to any planned improvements that would impact the design and construction process.




BUS ALTERNATIVES
ALTERNATIVE 4
ALTERNATIVE 5
ALTERNATIVE 6
PUBLIC OPEN HOUSE


HEAVY RAIL ALTERNATIVES
SUBWAY ALIGNMENTS
ROUSE ALIGNMENT
11TH & CONSTITUTION ALIGNMENT
BROAD & KITTY HAWK ALIGNMENT
PUBLIC OPEN HOUSE


CURRENT RECOMMENDATIONS
Phasing
PUBLIC OPEN HOUSE
Phasing
Immediate Term: Better Multi-modal Access at NRG Station
Explore:
• Dedicated curb space and pull off areas for shuttle buses in close proximity to station exits
• Enhanced shuttle signage within and around the station
• Opportunity for cross promotion of SEPTA and Navy Yard Shuttle services
• Better bike and pedestrian facilities connecting NRG station to the Navy Yard
• Provision of better amenities at bus stops adjacent to NRG station
Existing Bike facilities
The existing shuttle has been very successful. Ridership could further increase with improved and easier access between SEPTA and the shuttles.
Short Term: Enhanced Shuttle Frequency at Jefferson Station and NRG Station
Recommend:
• Advancing Alternative 4 for additional route planning and study
• Further supporting Alternative 4 with SEPTA support of the proposed Navy Yard TMA
Alternative 4
Alternative 4 was identified as the most cost-effective bus scenario in terms of benefits relative to the operating costs.
Navy Yard Shuttle
Medium Term: Incremental Growth of Shuttle/Bus Access to the Navy Yard
Assess:
• Service to see if the frequency, areas served, additional shuttle origins, or hours of service should be increased
• The feasibility of other modes, such as Bus Rapid Transit and Light rail, to serve the Navy Yard, stadium area, FDR Park, and adjacent residential areas
• The potential for SEPTA to take over operations
Must prepare for the point in time when the shuttle bus demand exceeds that of capacity.
Birds Eye View of Navy Yard & Adjacent Areas
Long Term: Broad Street Subway Extension
Revisit:
• The FTA New Starts Rating analysis as the Navy Yard grows and the transportation funding landscape changes
• The Broad Street Subway Extension Scenarios if any of the following occurs:
• Funds other than the FTA New Starts Funds become available to advance the project
• Changes in federal programs from the current FTA process (2018)
• Significant changes in development (employment or population) at the Navy Yard
• Significant changes to the Navy Yard Master Plan
Based on existing Navy Yard conditions, none of the three subway scenarios would obtain an overall Medium rating needed to seek admittance into the FTA New Starts Funding Program.
Construction of 400 S. 26th Street
As the Navy Yard and shuttle ridership continues to grow, more efficient modes of transit should continue to be pursued.

# 9 CONCLUSION

Ever since the Philadelphia Navy Yard ceased to be an active military base in 1995, multiple redevelopment plans for transformation of The Navy Yard for ship building, offices, and residential purposes have been completed. The Navy Yard is thriving, transitioning from a military center to a vibrant mix of industries, cutting edge office buildings, and planned residential developments. The extension of the Broad Street Line from NRG Station to The Navy Yard has been perceived as one of the critical transportation infrastructure investments needed to support an accelerated repurposing of The Navy Yard. Any future significant increase in residential and commercial uses at The Navy Yard would warrant and be dependent on provision of a better transit connection to Center City Philadelphia and SEPTA's regional rail system. The Phase 2 Feasibility Study was undertaken to evaluate the viability for extending the BSL into The Navy Yard, following in the footsteps of other recent studies evaluating the feasibility of the project, including the Philadelphia Navy Yard Master Plan (2004), the Broad Street Line Extension Feasibility Study (2008), Philadelphia2035: The Citywide Vision (2011), Philadelphia2035: Lower South District Plan (2012), and The Navy Yard Master Plan Update (2013).

The project would address the increased transit demand in The Navy Yard; the employment in The Navy Yard is projected to increase from over 11,000 today to 36,000 in 2040, while the number of residential units is projected to increase to 3,000. The existing bus shuttles would not be able to handle the new riders, and providing enough parking for commuters and residents would limit development. This feasibility study shows that, in 2040, BSLX could count on strong induced ridership, with forecasted range of daily linked trips on the project from a high of 11,400 trips in 2040 Build Alternative 2, to a low of 7,900 trips in Alternative 6. The estimated capital improvement costs for the subway extension range from $984 million for Alternative 1 - the Rouse Boulevard Alignment, to $1.82 billion for Alternative 3 - the Broad Street and Kitty Hawk Avenue Alignment. The bus scenarios include minimal capital investment, with Alternative 4 identified to be the most cost-effective in terms of its benefits relative to the operating costs.

Without committing to a locally preferred alternative at this point, the preliminary New Starts analysis shows that the subway extension scenarios are likely to obtain at least a favorable rating in the congestion relief, environmental benefits, and economic development project justification criteria. **Alternative 1** would likely receive the highest rating in categories of cost efficiency and mobility – a function of lower capital cost and relatively high ridership projections when compared to the other two alignments. **However, none of the three subway scenarios would obtain an overall Medium rating needed to seek admittance into the FTA funding program, based on the existing conditions within The Navy Yard.** This is due primarily to the fact that the anticipated ridership is not high enough for the estimated construction cost.

These recommendations should be re-visited if any of the following conditions are met:

- Availability of funds outside of the current (2017) FTA New Starts Process;
- Changes in federal programs from the current (2017) FTA Processes;
- Significant changes in development (population or employment) in The Navy Yard;
- Significant changes to The Navy Yard Master Plan.

Under any of the above scenarios the project could be viable and Alternative 1, with one subway station in The Navy Yard, would be recommended for further analysis.

On the bus side, Alternative 4 was identified as the most cost-effective bus scenario in terms of benefits relative to the operating costs. The results of this study indicate that improving bus access to The Navy Yard would be a viable, feasible and cost-effective solution to meet the project's Purpose & Need. As a result, it is recommended to advance these alternatives for additional route planning and study. Feedback received at the public open house indicated an interest in maintaining the existing express bus service from Center City, which was not included in the recommended Alternative 4. It is recommended that the existing express bus service continue with the enhanced shuttle loop operation.

The Phase 2 Feasibility Study examines the project at a conceptual level, posing and addressing questions about the feasibility of alternatives and their comparative merits and benefits. If this project is advanced to a construction phase, a locally preferred alternative would be selected via completion of a more refined Alternative Analysis Study, followed by draft environmental documentation, Preliminary Engineering, and development of the Final Environmental Impact Statement. If New Starts funding is pursued for the project, a complete FTA New Starts Financial Analysis will need to be completed and the local match funding would need to be secured. This process would also include extensive public involvement opportunities and extensive coordination with the stakeholders.

# APPENDIX A

BROAD STREET SUBWAY LINE EXTENSION TO THE NAVY YARD – POTENTIAL ALIGNMENTS STAKEHOLDERS MEETING SUMMARY (JUNE 2015)

MEMORANDUM

Subject
Summary of Purpose and Need Statement and Potential Alignments Meeting for the Broad Street Line Subway Extension to the Philadelphia Navy Yard- Friday June 12, 2015

Date
6/30/2015

## Introduction/Purpose

This memorandum summarizes the *Purpose and Need Statement and Potential Alignments* Meeting scheduled on June 12, 2015 (11 am to 2 pm).

Michael Baker, Inc. (Troy Truax) prepared materials for the Purpose and Need Statement segment of the three-hour meeting; HNTB prepared materials for the Potential Alignment segment of the meeting.

## Context

The meeting was attended by three SEPTA representatives, one City of Philadelphia representative, one PennDOT representative, one DVRPC representative, two PIDC/Navy Yard representatives, three Michael Baker, Inc. representatives and four HNTB Corporation representatives. The meeting was held in two sessions; to discuss and define the purpose and need statement and to choose potential alignments and potential stops for the Broad Street Line Subway Extension (BSLX) to The Navy Yard.

## Purpose and Needs Statement

Employees from Michael Baker, Jr. presented the most recent Purpose and Need Statement (P&N), and a discussion followed to determine the most fitting purpose(s) and need(s) for the New Starts application. Michael Baker, Inc. recorded comments and will follow up with the group when the comments are compiled and received from SEPTA.

## Potential Alignments

HNTB Corporation (David Hollis) led the discussion during the potential alignments session of the workshop. The purpose of the session was to identify the potential alignments of an extension of the Broad Street Line subway into The Navy Yard, taking account of 1) the existing and targeted employment and residential populations within The Navy Yard, 2) the transit needs in sports complex area, 3) the existing buildings and roadway network, and 4) other constraints. The project team was tasked with the responsibility of identifying potential subway alignments into The Navy Yard, considering several constraints: I-95 and entry points to The Navy Yard, preliminary environmental screenings, existing buildings and roadways, and potential construction costs.

The project team divided into two groups and 24" x 36" maps were given to each group, along with markers, pens, post-it notes and two plastic circles (designed to provide a quarter-mile radius/half-mile diameter to envision the maximum trip distance most pedestrians are willing to walk). The groups were instructed to discuss potential alignments and indicate their preferences by drawing potential routes and stops directly on the map. The results of the breakout session are explained below.

Figure 1: Group 1 Potential Alignments


Figure 1 above illustrates four potential alignments by Group 1 of the workshop; the first (green line) features one stop at the intersection of Kitty Hawk Avenue and Broad Street, with the subway route operating along Broad Street. The blue line features two stops, one at the intersection of 13th Street and Constitution Avenue, and the other stop near the intersection of League Island Boulevard and Kitty Hawk Avenue with the subway route connecting the two stops. The red line also features two stops, one at the intersection of 12th Street and Normandy Place, and the other stop near the intersection of Muslin Park West and Kitty Hawk Avenue, the subway route also connecting the two stops. The black line features one stop near the intersection of Muslin Park West and Kitty Hawk Avenue with the subway route operating along Rouse Boulevard.

Figure 2: Group 2 Potential Alignments

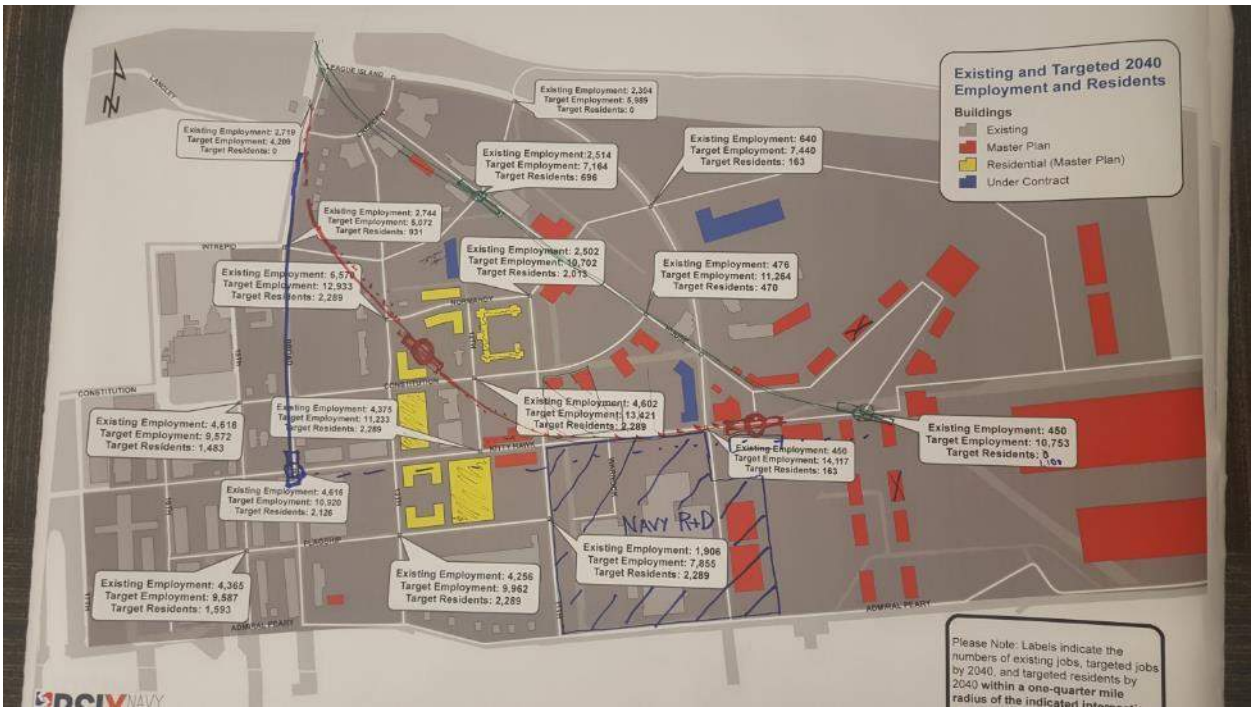
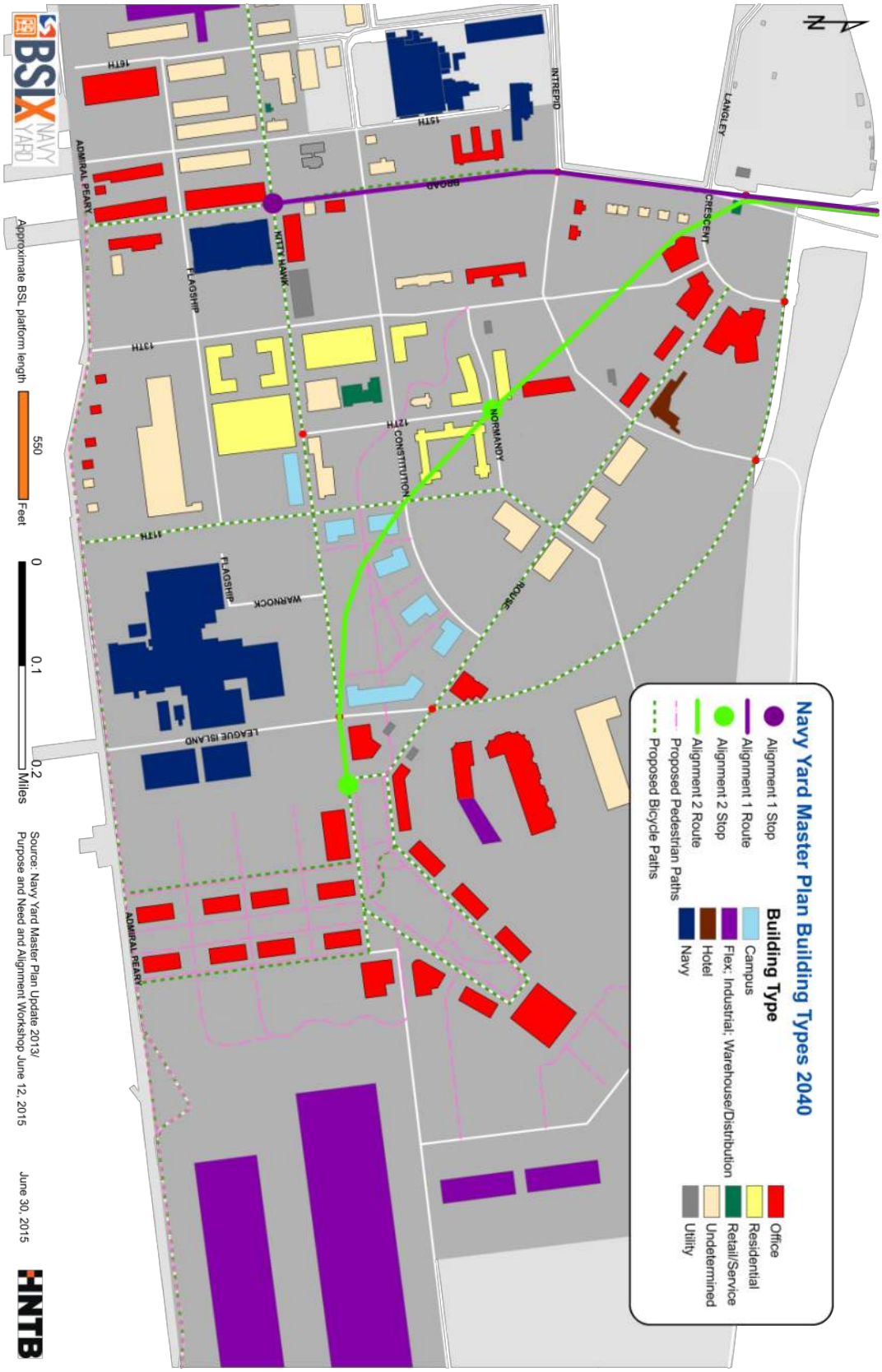



Figure 2 illustrates three potential alignments by Group 2 of the workshop. The blue line on the far left of the map features one stop at the intersection of Kitty Hawk Avenue and Broad Street, with the subway route operating along Broad Street. The red line features two stops, the first located in the center of a proposed residential area between 12th and 13th Streets near Normandy Place. The second stop is located at the intersection of Muslin Park West and Kitty Hawk Avenue. The green line also features two stops, one at the intersection of Rouse Boulevard and Intrepid Avenue, and the second stop located at the intersection of Muslin Park East and Kitty Hawk Avenue.

After comparing the groups' suggested alignments, the workshop attendees recommended two alignments; Alignment 1, one potential stop at Broad Street and Kitty Hawk Avenue, with the subway route along Broad Street, and Alignment 2, two potential stops, one at the intersection of 12th Street and Normandy Place, and the other stop near the intersection of Muslin Park West and Kitty Hawk Avenue, with the route connecting the two stops. The two alignments were imported into ArcMap following the workshop and the result is illustrated in Figure 3 below.

Figure 3: Recommended Potential Alignments Map



The two recommended alignments were selected based on several attributes. Alignment 1, with one stop along Broad Street could provide a one-seat trip for the existing, populated employment area near the intersection of Broad Street and Kitty Hawk Avenue; and Alignment 2, with two stops at the intersections of 12th Street and Normandy Place, and Muslin Park West and Kitty Hawk Avenue could capture the highest number of targeted residents within The Navy Yard, and could provide a one-seat trip for future Navy Yard development in the Mustin Park, Canal, and Port Districts. The second stop in Alignment 2 was also recommended to account for a potential subway line extension beyond The Navy Yard into New Jersey, not included in this project's scope of work.

# APPENDIX B

TECHNICAL MEMORANDUM – ENGINEERING ANALYSIS, CAPITAL COST ESTIMATE AND CONCEPTUAL PLANS

pennsylvania
DEPARTMENT OF TRANSPORTATION

**PENNSYLVANIA**

**DEPARTMENT OF TRANSPORTATION**

Bureau of Public Transportation

E03137 - WO#8 - Task 1.5

# Broad Street Subway Extension to the Philadelphia Navy Yard

## Technical Memorandum – Engineering Analysis, Capital Cost Estimate and Conceptual Plans

**February 13, 2017**

**Rev January 19, 2018**

PREPARED FOR

**Pennsylvania Department of Transportation**

PREPARED BY

**HNTB Corporation**

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**Revision History**

Project Name: Broad Street Subway Extension to the Philadelphia Navy Yard
Partners: PennDOT, Bureau of Public Transportation – HNTB Corporation
Project Location: City of Philadelphia, Pennsylvania

| Revision Supplement | Date | Comments/Revisions Made |
|---|---|---|
| Original Draft | 2/13/2017 | Issued |
| Revised Draft | 1/19/2018 | Issued - Revised to include contingencies |

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# I. EXECUTIVE SUMMARY

The enclosed technical memorandum provides documentation of the technical assumptions and approaches used to develop the three conceptual designs and construction cost estimates for the proposed SEPTA Broad Street Subway Extension to Philadelphia Navy Yard (BSLX). This information is intended to be used as supporting documentation for a mock FTA New Starts application. Based on the alignment development and technical analyses, the three alternative alignments are summarized as follows utilizing FTA Guidelines on probable accuracy and allocated contingency:

| Alignment | Guideway Length | # of Stations | Estimate with Contingency |
|---|---|---|---|
| Rouse Boulevard | 4,800 LF | 1 | $869M |
| 13th Street & Constitution Ave | 8,100 LF | 2 | $1,503M |
| Broad Street & Kitty Hawk Ave | 9,300 LF | 2 | $1,601M |

**Table 1. Broad Street Line Alternatives summarized using FTA Guidelines**

This technical memorandum, originally issued February 2017, has been revised to include contingencies allocated across SCC code based on level of information and risk.

## II. PURPOSE

The purpose of this memorandum is to provide supporting documentation for the technical assumptions made in the conceptual design and construction cost estimate for the proposed SEPTA Broad Street Subway Extension to Philadelphia Navy Yard (BSLX). This memorandum in intended to be incorporated into the overall Plan as an Appendix.

## III. IDENTIFICATION OF ALIGNMENTS STUDIED

Based on numerous meetings with the Steering Committee, the three alternatives (See Attachment #1) below were identified to be studied further due to the potential for future ridership (Please note all three alternatives below follow the same alignment from AT&T station to just south of I-95):

1. Rouse Boulevard (See Attachment #1 - Plan S-1 and S-2) – extending from AT&T Station southward into the Navy Yard, with one station at Rouse Boulevard adjacent to Central Green (between Intrepid Avenue and Normandy Place);
2. 13th Street (See Attachment #1 - Plan S-1 and S-3) – extending from AT&T Station southward into the Navy Yard down 13th Street before curving eastward along Constitution Avenue and Kitty Hawk Avenue. Two stations would be constructed: one on 13th Street between Intrepid Avenue and Normandy Place; and the second on Kitty Hawk Avenue, east of League Island Boulevard;
3. Broad Street (See Attachment #1 - Plan S-1 and S-4) – extending from AT&T Station southward into the Navy Yard along Broad Street before curving eastward along Kitty Hawk Avenue. The first station would be on Broad Street between Intrepid Avenue and Constitution Avenue, the second station on Kitty Hawk Avenue, east of League Island Boulevard.

One of the largest constraints to extending the Broad Street Line into the Navy Yard is crossing Interstate 95 (I-95) and CSX freight rail tracks located immediately south of AT&T Station/Stadium District. I-95 is carried on a viaduct over 11th Street, with ramps connecting to Broad Street. The CSX freight tracks pass under Broad Street, south of I-95 in an open cut. The I-95 ramps are built on pile-supported retained fill. PennDOT constructed a single bridge span into the ramps to facilitate the future extension of the Broad Street Line.

During the early stages of alignment planning, alternatives for crossing I-95 and entering the Navy Yard were evaluated with the Steering Committee. In addition to the sub-surface alignment, alterative alignments at-grade along Broad Street and aerial over I-95 were considered. However, it was determined that neither surface running nor an aerial guideway would be compatible with the planned development of the Navy Yard. A flyover of I-95/CSX was eliminated from consideration as it would require that the extension continue on aerial structure in the Navy Yard. Consideration was given to crossing with a combination of shallow tunnel under I-95 and aerial structure over CSX, but the grades and clearances did not allow for such a crossing without impact to the I-95 ramps. Therefore, tunneling beneath both I-95 and CSX was the only option that was considered for all Navy Yard alignment alternatives.

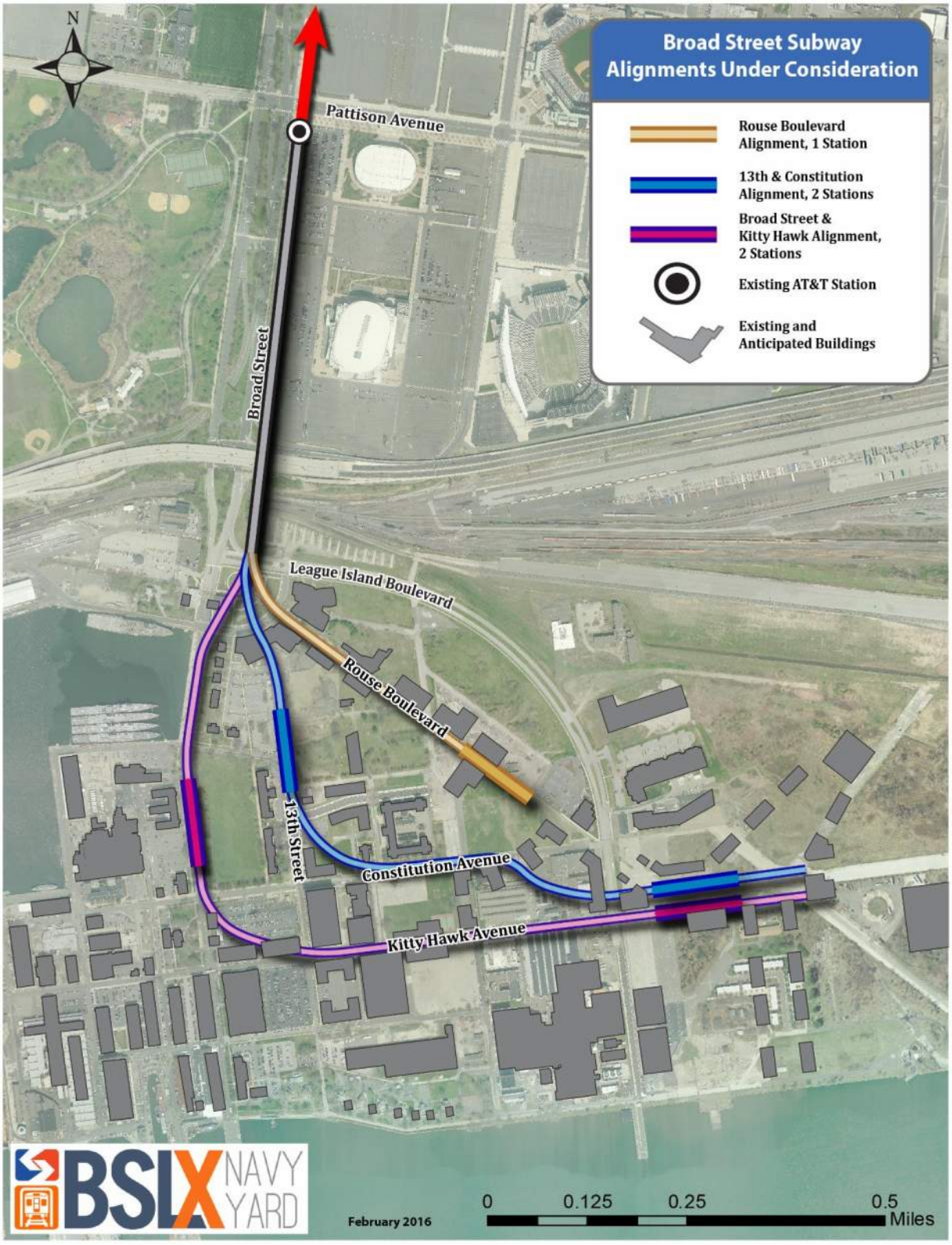


Figure 1. BSLX Alternatives

# IV. TECHNICAL ANALYSIS

## IV.1 TRACK AND TUNNEL DESIGN

### TRACK TECHNICAL DESIGN

The track design for the Broad Street Extension assumes that the running rails for track and special track work (crossovers) will be constructed using light rail (115RE tee rail section type) and for curves under 1,000-foot radius and all special track work it is assumed that head hardened rail is required.

Each alternative has been designed to be constructed entirely in tunnel, so all track and special track work construction is anticipated to be non-ballasted/direct fixation. This analysis did not identify a specific non-ballasted track system for use in tunnels, but in order to not preclude any of the common track types a minimum depth from top of rail to tunnel invert of 20 inches was maintained.

A combination of turnouts and crossovers (No.8 and No.11) based on assumed speeds have been used in developing the alternatives. Tunnel construction and limited tangent necessitated the use of double crossovers. Curves with radius under 1,000 feet are included in each alternative, requiring the installation of restraining guard rail. Friction management systems will be required for each alternative. The location and type of lubricator should be determined for the preferred alternative in the next phase of design.

#### HORIZONTAL ALIGNMENT

Under current SEPTA design standards for the Broad Street Line a minimum radius of 200 feet on mainline track is required. However, for the purposes of this study, a practical minimum of 550 feet was used in developing the alignments to allow for the use of Tunnel Boring Machine (TBM) technology. Using a 550-foot minimum radius had the additional benefits of avoiding the need for gauge widening (required for curves under 500-foot radius) and limiting the civil speed restrictions on the line to a minimum of 25 mph.

Curves with radius greater than 1,000 feet have been designed using spiral transitions in increments of 31 feet with a minimum length of 62 feet, as recommended by the AREMA Manual. Multicenter compound-curve spirals, as defined in SEPTA's City Transit Division (CTD) Standards, are used for transitions to curves with radius under 1,000 feet. All 550-foot radius curves have been designed for a minimum speed of 25 mph, which is the maximum speed achievable within the design criteria, keeping superelevation runout within the spiral transition. These curves may be increased to 30 mph if an additional 1 inch of superelevation is runout in the tangent. This is allowable for the Broad Street Line but was not included in the design at this time. The geometry of the preferred alternative should be refined in the next design phase to optimize speed and constructability.

#### VERTICAL ALIGNMENT

The profiles for each alternative were designed with grades less than the maximum allowable of 2.5%. Mainline vertical curves meet the minimum radius of 5,000 feet for summits and 10,000 feet for sags (an exception is required for a non-revenue move in the stadium district). Tangent lengths meet or exceed the minimum required of 100 feet for all alternatives.

### FIRE PROTECTION

Cross passages are provided between the two tunnels to allow for emergency exits. The spacing of the cross passages are based on the most recent NFPA requirements and are placed at a maximum spacing of 800 feet.

### PUMP STATIONS

Due to the length and vertical profile of the subway extension, along with the relatively shallow groundwater table, several pump stations are anticipated to keep the tunnel dry. Pump stations are located based on the following considerations:

- Vertical low points;
- Combining the pump station facilities with other subway support facilities;
- Separate pump stations for outside the Act 2 Special Industrial Area (SIA) and within the Act 2 SIA (within the Navy Yard);
- Maximizing the potential phasing of the extension (one station at a time);
- Reasonableness of pump station spacing.

As a result, multiple pump stations are proposed and noted on the conceptual plans.

## TUNNELING ALTERNATIVES

Based on the preliminary geotechnical data available two methods of tunnel excavation were considered, cut-and-cover and tunnel boring machine (TBM). Each method presents limitations on the track alignment, so determination of the preferred method was critical to the development of the alternatives.

Cut-and-cover tunneling is a method of top-down construction that requires the alignment to avoid existing surface development, remaining primarily in street right of way. Such an alignment would require tight curves and low speeds. Excavation within streets would be disruptive to local traffic and require relocation of subsurface utilities. Furthermore, cut-and-cover tunneling to cross CSX would be disruptive to railroad operations and was found to be infeasible so another method, such as sequential excavation, would need to be utilized for that section of the tunnel.

TBM avoids many of the problems presented by cut-and-cover, with the primary benefit of minimizing impacts on the surface. The TBM can navigate between the launch and extraction pits without the need for additional surface excavation. Earth Pressure Balance Machines (EPBM), a type of TBM, can be used to tunnel under existing infrastructure and development without compromising the structural integrity of those structures. This is particularly beneficial for the I-95/CSX crossing as it affects each alternative. This EPBM also reduces the geometric constraint of running only within streets. TBM does restrict the track geometry, limiting horizontal curves to a minimum radius of 550 feet and requiring the track be built deep enough to maintain a minimum cover of one tunnel diameter.

TBM has a large initial cost for procurement of the machine, but the reduced surface/utility impacts and higher production rate result in cost savings compared to cut-and-cover for longer tunnels. The shortest alternative studied calls for approximately 4,000 feet of bored tunnel, which supports the use of TBM. The longer alternatives (up to approximately 9,000 feet of bored tunnel) have even lower costs per mile. For

these reasons TBM was selected as the preferred tunnel excavation method. The alignments were developed based on the constraints of TBM construction.

It is possible to use a single TBM to bore a two-track tunnel. For the Broad Street Line this would mean a 36-foot diameter tunnel requirement. Alternatively, two single-track tunnels, each 21 feet, could be used. The use of a single TBM, though feasible, is undesirable as it increases the construction cost for several reasons. First, the larger tunnel increases spoils by nearly 50% compared with two smaller tunnels, handling and disposal of which will be a major factor in the construction cost and environmental impact of the project. The larger diameter tunnel will also need to be constructed deeper to achieve one diameter of cover. This forces stations and interlockings to be constructed deeper, also increasing construction cost. These costs offset savings that may be realized from the purchase of a single TBM. Two single-track tunnels have the added benefit of providing redundancy, allowing for single track operation during tunnel maintenance. In order to meet the fire life safety requirements of NFPA, cross passage between the two tunnels will need to be constructed, at a maximum spacing of 800 feet.

For all alternatives studied it is preferred to launch the TBM from the stadium district. The launch pit requires a large, open cut. Spoils from the TBM are transported back to the launch pit and requires area for stockpiling and removal. South of the existing terminal at AT&T Station is the surface parking lot for the Wells Fargo Center. Construction of a launch pit and mucking operation in this location would only displaces surface parking for the arena, which may be offset with parking at either the neighboring Citizens Bank Park or Lincoln Financial Field during construction. Extraction of the TBM would consequently be at the new Navy Yard terminus, the location of which varies for each alternative.

Excavation from the surface will be required for locations that require surface access or large, open underground areas. This includes stations, which will be constructed using the cut-and-cover method to create open space for platforms and concourses. Interlockings will be built using cut-and-cover as well to create space for crossover tracks between the mainlines. Ventilation shafts for fan plants and emergency egress at cross passages will also require excavation from the surface.

## ASSESSMENT OF TRACK AND TUNNEL TECHNICAL ASSUMPTIONS ON DESIGN

### STADIUM DISTRICT

The stadium district will serve an important function for Broad Street Line operations regardless of the Navy Yard alignment alternative selected. The existing AT&T station is two levels with two stub-ended tracks on each level. Passenger service is limited to the upper level because of accessibility constraints. The lower level is used for storage, but trains must be maneuvered through Pattison Interlocking reach the upper level, which ties up operations on the mainline. Providing access to both levels at the south end of AT&T Station and additional storage for special event service are one of the operational goals for the extension of the Broad Street Line.

Several alignment options were considered, but ultimately the constraints of the existing station geometry and the I-95/CSX crossing resulted in a single preferred alignment that can be paired with any of the alternatives within the Navy Yard. Tracks 1 and 4 are extended from the upper level of AT&T Station in a cut-and-cover tunnel through a new interlocking, after which the tracks descend in bored tunnels at a

2.3% grade passing under the I-95 piles and the CSX tracks into the Navy Yard. Tracks 2 and 3 are extended from the lower level and quickly rise between Tracks 1 and 4 and meet at the new interlocking. Tracks 2 and 3 continue in a shallow cut-and-cover tunnel and stub-end north of I-95, providing 600 feet of storage on each, enough for two consists. This configuration provides SEPTA with the desired operational improvements, makes efficient use of the Tunnel Boring Machine (TBM) launch pit for construction of the new interlocking, and integrates seamlessly with the Navy Yard extension regardless of the alignment alternative selected.

### NAVY YARD ALTERNATIVES

South of the I-95/CSX crossing several alignments were considered to provide the desired service to the Navy Yard. Three alignment alternatives were developed for this report.

## ROUSE BOULEVARD ALTERNATIVE

The first alternative considered followed Rouse Boulevard, which runs diagonally through the Navy Yard southeast from Crescent Park. This corridor had originally been envisioned as the location of a Broad Street Line extension, with utilities located clear of a potential cut-and-cover tunnel. Initially, a two-station alternative was considered for Rouse Boulevard, with a terminal east of League Island Boulevard and an intermediate station on Rouse Boulevard. These locations were found to be too close together, resulting in overlapping passenger shed areas, which impacts the effective coverage of the service area. The Rouse Boulevard Alternative was reduced to a single station, to be located at the intersection of Rouse Boulevard and Normandy Pl.

The alignment of the Rouse Boulevard Alternative continues the bored tunnels south of the CSX crossing through a short tangent, followed by a 550-foot radius curve under Crescent Park into Rouse Boulevard, continuing on tangent southeast to Normandy Pl. The track/tunnel alignment is constrained by existing development along both sides of Rouse Boulevard. A No.11 double crossover was included north of the station platform to allow access to/from either station track.

## 13TH STREET ALTERNATIVE

A longer route was developed in order to provide a two-station alternative that achieved wider coverage in the Navy Yard. This alignment follows 13th Street and Constitution Avenue, with a terminal east of League Island Boulevard and an intermediate station located on a tangent along 13th Street at Intrepid Avenue. The alignment is constrained by new development along 13th Street at the north end. The alignment also crosses an existing pile-supported concrete box drainage culvert and will require the relocation of a sanitary sewer pump station.

Another constraint on the alignment is the Naval Base Chapel located at 12th Street and Constitution Avenue. To avoid the chapel, the tunnel follows a 550-foot radius curve from 13th Street on to Constitution. This is followed by a reverse curve through an area of planned development to the terminal east of League Island Boulevard. Unlike the Rouse Boulevard Alternative, where train turns occur at the station, this alternative extends the tunnels east of the platform, with a No.8 double crossover followed

by two 600-foot stub-end turn tracks. This allows turns on non-revenue track and provides off peak storage for two consists.

### BROAD STREET ALTERNATIVE

In order to better serve existing business in the southwest area of the Navy Yard, a third alternative was developed. The alignment takes the tunnels from the CSX crossing south onto Broad Street, continuing south to Kitty Hawk Avenue where the tunnels turn east and continue to a terminal east of League Island Boulevard, similar to the 13th Street Alternative. An intermediate station is located on Broad Street between Intrepid and Constitution Avenues.

The alignment passes through the older Navy Yard developments. Like the 13th Street Alternative, the tunnel crosses the pile-supported concrete box drainage culvert. The alignment parallels the existing quay wall along the Reserve Basin. The tunnel must be coordinated with the quay wall design, that require tie backs. Another constraint on the alignment are the Marine Parade Grounds. This is a contributing historic resource and must be preserved. The intermediate station will be located on the western edge of the Marine Parade Grounds.

An existing fire house at Kitty Hawk Avenue and 13th Street is in the path of the proposed tunnels and would need to be relocated. Other buildings that are close to the proposed tunnel will require underpinning and monitoring during construction. The proposed alignment passes close to a Navy research facility, requiring coordination with Navy to ensure security and limited disturbance to the facility during construction.

## IV.2 STATIONS

The primary factor in the location of the stations was maximizing the rider shed. To do so, the proposed station should be located in close proximity to the existing/planned development and be spaced far enough apart so that the rider sheds do not overlap (at least 0.5 mile between nearest entrances). The stations should also be centered within the development, since stations on the edge have diminished coverage. This eliminated the idea of running the line down League Island Boulevard, along the northern/eastern edge of development. The track geometry was a second factor in the location of stations. The geometry was developed to locate tangents as close as possible to the optimal station locations.

Platforms have been designed to the minimum length of 550 feet, located on tangent, level track for each alternative. Initially, both side and center island platform configurations were considered. Center island platforms are preferred by SEPTA as they provide more operational flexibility than side platforms, particularly for single track operations during work outages. In addition, the use of Tunnel Boring Machine (TBM) technology necessitates a minimum depth of cover, which facilitates the inclusion of a concourse level and center island platforms under existing streets. Side platforms are well suited for shallow, cut-and-cover systems running under the street level and undeveloped areas as they allow platform access from sidewalks without the need for concourses.

The terminal station for the Rouse Boulevard Alternative, as well as the intermediate stations for the 13th Street and Broad Street Alternatives, consists of a center island platform with concourses. Access buildings are located at each end of the station for Rouse Boulevard and 13th Street where space is available. Broad Street, which is constrained by the historic Marine Parade Grounds and existing buildings, has one access building at the south end of the station, with access stairs to the street at the north end. Access buildings will provide ADA compliant accessibility to the station concourses and will be integrated with the fan plants and pump stations.

The terminal station for the 13th Street and Broad Street Alternatives will be located in a currently undeveloped area of the Navy Yard. This presents an opportunity to eliminate the concourse and provide direct access to the center platforms through head houses located at each end of the station. This reduces the depth of excavation, construction and operating costs.

Both one and two-level stations are proposed as cut-and-cover box sections. TBM may be used to bore the initial tunnels, with the station concourse and platform area excavated from the surface. In this sequence the TBM tunnel liners will be removed once the material is excavated from above. The box will be reinforced concrete. The two-level station has a 3'-9" thick bottom slab with 3' thick walls. The box is topped with a 3' thick top slab and a minimum 8 feet of surface cover, which provides space for buried utilities to cross. The minimum depth from top of rail to surface for two-level stations is 44'-6", which provides 16' clearance for the concourse and 11'-6" clearance above the high-level platform.

The single-level station has a minimum depth of 33'-9", with 15' of cover. The extra depth is to allow for the use of the TBM for the initial excavation. The additional load of the cover increases the top slab thickness to 4' and the walls to 3'-6". Space is provided at each end of the platform within the station box to locate communication and signal equipment between the tracks.

## IV.3 GEOTECHNICAL ANALYSIS

The majority of this project is located in the Navy Yard at the southern tip of Philadelphia. This site was previously an active military base that was closed during the Base Realignment and Closure Commission (BRACC) consolidation and turned over to the City of Philadelphia for economic development. As discussed in the supporting Environmental Document Review, some areas of known subsurface constraints have been identified. In addition, the entire Navy Yard has been designated as an Act 2 Special Industrial Area, providing some additional regulatory oversight. For example, based on the current agreement all excavated soils within the Navy Yard shall remain within the boundaries of the Navy Yard, or require disposal at a regulated facility.

In addition, this site is immediately adjacent to the Delaware and Schuylkill Rivers and the groundwater table throughout the entire site is relatively shallow, generally varying from 5'-10' below the existing ground. As a result of the shallow groundwater table, the tunnel will need to be designed to resist the buoyancy forces. In addition, the groundwater is tidally influenced and construction will require dewatering, likely on a constant basis.

The SEPTA BSLX project site lies in the Coastal Plains Physiographic Province with surficial geology primarily attributed to the Wisconsinan glaciation. The project site generally consists of artificial fill

underlain by estuarine and salt-marsh deposits, alluvial deposits and glaciofluvial sediments that are underlain by the Potomac Formation. Bedrock at the project site is generally encountered at depths greater than 100 feet.

From the connection to the existing Broad Street Line extending southward under I-95 and the adjacent railroad tracks, the three alternatives share a common section of alignment from STA 0+00 to STA 24+00, denoted as the Stadium District.

### STADIUM DISTRICT

This portion of alignment contains an interlocking, storage tracks and the tunnel boring machine (TBM) launch pit. The base of the cut and cover section is situated in the glaciofluvial deposits.

| Stadium District Alternative | | |
|---|---|---|
| Stratum | Description | Thickness |
| 1 | Miscellaneous Fill | 15' - 28' |
| 2 | Salt Marsh and Estuarine Deposits | 6' - 10' |
| 3 | Alluvial Soils | * |
| * | Existing boring information terminated in this stratum | |

**Table 2. Stadium District Geotechnical Data Summary**

South of the Stadium District, the three alternatives have separate alignments, each encountering differing subsurface strata.

### ROUSE BOULEVARD ALTERNATIVE

The Rouse Boulevard Alternative connects to the Stadium District described above and turns southeast underneath Rouse Boulevard before terminating at a station between Normandy Place and League Island Boulevard. This portion of the alignment contains an interlocking and the TBM receiving pit. The station is located in the cut and cover portion at the TBM receiving pit. This alternative encounters four major strata including:

| Rouse Boulevard Alternative | | |
|---|---|---|
| Stratum | Description | Thickness |
| 1 | Miscellaneous Fill | 4' - 12' |
| 2 | Salt Marsh and Estuarine Deposits | 15' - 40' |
| 3 | Alluvial Soils* | 7' - 10' |
| 4 | Trenton Gravel (Glaciofluvial) | ** |
| * | Isolated Pockets | |
| ** | Existing boring information terminated in this stratum | |

**Table 3. Rouse Boulevard Geotechnical Data Summary**

The bottom of the tunnel and the cut and cover elevations are situated partially through the second stratum and partially through and bears on the fourth stratum. The third stratum is present in isolated pockets.

### 13TH STREET AND CONSTITUTION AVENUE ALTERNATIVE

The 13th Street and Constitution Alternative connects to the Stadium District described above and extends southward along 13th Street before turning east along Constitution Avenue, following a curved alignment to Kitty Hawk Avenue. This portion of the alignment contains a two-level station along 13th Street, and an interlocking and one-level station located at the TBM receiving pit along Kitty Hawk Avenue east of League Island Boulevard. Both stations are by cut and cover methods. This alternative encounters five major strata including:

| 13th Street and Constitution Avenue Alternative (before Sta 34+00) | | |
|---|---|---|
| Stratum | Description | Thickness |
| 1 | Miscellaneous Fill | 4' - 12' |
| 2 | Salt Marsh and Estuarine Deposits | 15' - 20' |
| 3 | Trenton Gravel (Glaciofluvial) | * |
| * | Existing boring information terminated in this stratum | |

| 13th Street and Constitution Avenue Alternative (after Sta 34+00) | | |
|---|---|---|
| Stratum | Description | Thickness |
| 1 | Miscellaneous Fill | 4' - 12' |
| 2 | Salt Marsh and Estuarine Deposits | 15' - 20' |
| 3 | Alluvial Soils | 5' - 12' |
| 4 | Trenton Gravel (Glaciofluvial) | *, ** |
| 5 | Potomac Formation | *** |
| * | As thin as 7' | |
| ** | Most existing boring information terminated in this stratum | |
| *** | Present only from Sta 70+00 to 78+00 | |

**Table 4. 13th and Constitution Avenue Geotechnical Data Summary**

The bottom of the tunnel varies, being situated in the second stratum to the fourth stratum for much of the alignment before rising at the Kitty Hawk Avenue station to be entirely within the second stratum. From the Stadium District through the end of the first cut and cover tunnel at Station 41+00, this alignment's cross section remains entirely below the second stratum.

### BROAD STREET AND KITTY HAWK AVENUE ALTERNATIVE

The Broad Street and Kitty Hawk Avenue Alternative connects to the Stadium District described above and extends southward along Broad Street before turning east along Kitty Hawk Avenue. This portion of the

alignment contains a two-level station along Broad Street under the northbound lane and sidewalk adjacent to the Marine Parade Grounds, and an interlocking and one-level station located at the TBM receiving pit along Kitty Hawk Avenue east of League Island Boulevard. Both stations are by cut and cover methods. This alternative encounters the same five major strata as the 13th Street and Constitution Street Alternative including:

| Broad Street and Kitty Hawk Avenue Alternative (before Sta 37+00) | | |
|---|---|---|
| Stratum | Description | Thickness |
| 1 | Miscellaneous Fill | 4' - 12' |
| 2 | Salt Marsh and Estuarine Deposits | 5' - 20' |
| 3 | Alluvial Soils | 20' - 45' |
| 3 | Trenton Gravel (Glaciofluvial) | * |
| * | Existing boring information terminated in this stratum | |

| Broad Street and Kitty Hawk Avenue Alternative (after Sta 37+00) | | |
|---|---|---|
| Stratum | Description | Thickness |
| 1 | Miscellaneous Fill | 4' - 12' |
| 2 | Salt Marsh and Estuarine Deposits | 20' - 50' |
| 3 | Alluvial Soils | 5' - 12' |
| 4 | Trenton Gravel (Glaciofluvial) | *, ** |
| 5 | Potomac Formation | *** |
| * | As thin as 7' | |
| ** | Most existing boring information terminated in this stratum | |
| *** | Present only from Sta 78+00 to 84+00 | |

**Table 5. Broad Street and Kitty Hawk Avenue Geotechnical Data Summary**

The bottom of the tunnel is situated in the second stratum for much of the alignment.

## IV.4 CONSTRUCTABILITY ANALYSIS

Due to the geometric and site constraints, it was determined that most cost-effective construction method for this project was to utilize tunnel boring machines (TBM) in order to build the track alignment. As a result, horizontal and vertical geometries were limited to what is reasonable and feasible under current techniques. It is anticipated that the tunneling launch pit would be constructed in the parking lot of Wells Fargo Center and the TBM would be advanced for the full length of the alignments. It is anticipated that each station would be constructed utilizing cut-and-cover techniques.

As noted in the Geotechnical Analysis, the site exhibits a high groundwater table. As a result, constant dewatering during construction is anticipated. In addition, the Navy Yard is designated as an Act 2 Special Industrial Area. As a result, soils excavated from the Navy Yard are currently required to remain in the Navy Yard, or to be disposed of in a proper manner. As discussed later in this memorandum, significant

utility relocation will be necessary in order to facilitate the construction. This includes providing an adequate power supply for the TBM's.

## STADIUM DISTRICT

The TBM launch pit would be located immediately south of AT&T Station, within the parking lot of Wells Fargo Center. The cut-and-cover for the launch pit would allow for the construction of the interlockings at AT&T station connecting the lower and upper tracks, as well as the construction of the new storage tracks to the south. The TBM will continue to the south, under I-95 and the Conrail/CSX freight tracks, into the Navy Yard. The vertical profile through this area was developed in order to avoid impacts to I-95 and the freight tracks.

## NAVY YARD ALTERNATIVES

Each alternative within the Navy Yard are described separately. It is anticipated that pedestrian and vehicular traffic will be temporarily re-routed within the Navy Yard to accommodate the impacts associated with station construction.

### ROUSE BOULEVARD ALTERNATIVE

The Rouse Boulevard Alternative will require the station to be built utilizing cut-and-cover techniques between Intrepid Avenue and Constitution Avenue, approximately 1,135'. This will allow for the construction of an interlocking along the station approach, as well as a 550' long center platform station under Rouse Boulevard.

### 13TH STREET ALTERNATIVE

The 13th Street Alternative will require a station to be built utilizing cut-and-cover techniques under 13th Street at Intrepid Avenue, approximately 750' in length, to accommodate a center platform station. The TBM will advance along the proposed alignment to the Kitty Hawk Avenue station. This station, east of League Island Boulevard, will require approximately 1,615' of cut-and-cover construction to accommodate a 550' long center platform station and an interlocking after the station. This alignment will require that future construction in the Navy Yard be planned in order to accommodate the future subway extension. This alignment will require the relocation of the existing sanitary sewer pump station at the intersection of 13th Street and Normandy Place.

### BROAD STREET ALTERNATIVE

The Broad Street Alternative will require a station to be built utilizing cut-and-cover techniques under Broad Street at the Marine Parade Grounds, approximately 1,010' in length, to accommodate a center platform station. The TBM will advance along the proposed alignment to the Kitty Hawk Avenue station. This station, east of League Island Boulevard, will require approximately 1,550' of cut-and-cover construction to accommodate a 550' long center platform station and an interlocking after the station. This alignment will require that future construction in the Navy Yard be planned in order to accommodate the future subway extension. In addition, several buildings within the Navy Yard will need to be demolished, or supported to allow for the tunnel construction. This includes the relocation of the Navy Fire Station.

## IV.5 POWER ANALYSIS

The nearest existing SEPTA substation is located in AT&T Station. Along the Broad Street Line, the current spacing for substations is approximately 1 to 1 ½ miles. Within the Navy Yard limits, PIDC owns and operates an unregulated micro-grid system.

As a result, new substations are proposed at each new station, built within the structure or headhouse. It is assumed that the power supply for the substations will be fed through the new tunnels. This approach will allow for flexibility in the phasing of the extension.

Also, it is important to note the anticipated power supply necessary to support the tunneling operation. For each TBM, the necessary power supply is estimated to be 15 MW. This power will be supplied from the tunneling pit in the Stadium District.

## IV.6 UTILITIES

Each alternative will require significant utility relocation. It is anticipated that all pile-supported utilities (storm and sanitary sewer) over the tunnel will require reconstruction and/or relocation. In addition, utilities in and around the stations will require relocation. As the project advances into design phases, a cost comparison between relocating the pile-supported utilities and deepening the tunnel and stations should be performed.

In addition to the above, it is anticipated that the 13th Street Alternative will require the relocation of the existing sanitary sewer pump station at the intersection of 13th Street and Normandy Place. It is anticipated that this facility would be relocated to the corner of 12th Street and Normandy Place.

| Alternative | Utility Impacts/Considerations |
|---|---|
| Stadium District | I-95/CSX vertical clearance from foundations |
| Navy Yard – Rouse Blvd | Existing stormwater and sanitary on piles in Rouse Blvd. |
| Navy Yard – 13th Street | Existing stormwater and sanitary on piles in 13th Street |
| Navy Yard – Broad Street | Existing concrete box on piles Station 31+00; Proposed retaining wall with tie-backs along the Reserve Basin side of Broad Street; Existing stormwater and sanitary on piles in 11th, 12th & 13th Street crossing Kitty Hawk Avenue. |

Table 6. Alternative Utility Impact Summary

## IV.7 TRAFFIC CONTROL

This section will focus on the necessary impacts to maintain vehicular traffic around the construction sites. It is anticipated that pedestrians will be routed around the work zones in a safe and efficient manner.

## STADIUM DISTRICT

In order to facilitate construction, there will be long-term impacts to ingress/egress and parking at the Wells Fargo Center. Access impacts include Zinkoff Boulevard and the two driveways to the south. Parking impacts will be limited to the area west of Wells Fargo Center. It is anticipated that traffic circulation in and around the Stadium District can be modified in a manner which would minimize traffic impacts and congestion, however 1,000-1,500 spaces used for event parking for the Wells Fargo Center would be lost for approximately 2 or 3 construction seasons.

## NAVY YARD ALTERNATIVES

Each alternative within the Navy Yard will be presented separately. It is anticipated that bus routes will be temporarily re-routed within the Navy Yard to accommodate the impacts.

### ROUSE BOULEVARD ALTERNATIVE

In order to construct the station, Rouse Boulevard will need to be closed from Crescent Drive through Normandy Place. This will require directing traffic to Broad Street or League Island Boulevard and should not have a significant impact on access to the buildings and associated parking lots.

### 13TH STREET ALTERNATIVE

The 13th Street Alternative will require the closure of 13th Street from Crescent Drive through Normandy Place in order to construct the station. This will result in traffic diverting to Broad Street and Rouse Boulevard and should not have a significant impact on access to the buildings and associated parking lots. The second station, located along future Kitty Hawk Avenue, is planned for an area which is currently undeveloped.

### BROAD STREET ALTERNATIVE

The Broad Street Alternative will require the closure of Broad Street from Intrepid Avenue through Constitution Avenue in order to construct the first station. This will result in traffic diverting to League Island Boulevard. Temporary access to the Navy facilities on the west side of Broad Street may need to be considered. The second station, located along future Kitty Hawk Avenue, is planned for an area which is currently undeveloped.

## IV.8 ROW AND LAND ACQUISITION

It is anticipated that SEPTA will acquire right-of-way for the stations and supporting structures, and easements for the tunnel sections.

| Alternative | Approx. Required ROW (acres) | Additional ROW notes |
|---|---|---|
| Stadium District | 6 | Temporary Staging area for the TBM launch pit may require up to 10 additional acres |
| Navy Yard – Rouse Blvd | 4 | |
| Navy Yard – 13th Street | 9 | Additional ROW for the Relocation of existing Sanitary Sewer Pump Station may require 1 additional acre |
| Navy Yard – Broad Street | 10 | Additional ROW for the Relocation of existing Navy Fire Station may require 1 additional acre |

Table 7. Right of Way/Land Acquisition Summary

## IV.9 ROADWAY & SITE IMPACTS

In order to construct the tunnels, significant impacts and reconstruction is anticipated within the Wells Fargo Center parking lot. It is anticipated that the station construction will require full roadway reconstruction in the vicinity of the stations (Rouse Boulevard, 13th Street or Broad Street).

The 13th Street Alternative will require future accommodations within the future development parcel along the west side of League Island Boulevard, north of Kitty Hawk Avenue. It is anticipated that this will include adjusting the development footprint (without reducing the overall square footage) in order to accommodate the future tunnel. This alternative will also require close coordination with the future development on the east side of League Island Boulevard.

The Broad Street Alternative will require the relocation of the existing Navy Fire Station at the corner of Kitty Hawk Avenue and 12th Street. It is anticipated that the Fire Station could be relocated to the north side of the block. In addition, two one story buildings on the southeast corner of Broad Street and Constitution Avenue are anticipated to be demolished, while the building on the northeast corner of Broad Street and Kitty Hawk Avenue will require retrofitting and structural support due to the proximity of the tunnel.

# V. COST ESTIMATES

### BASIS OF ESTIMATES

The FTA Capital Cost Database (CCD) was utilized to generate Order of Magnitude estimates for each alternative. The FTA CCD contains "as-built" costs for a sample of light and heavy rail projects, with project costs and unit quantities recorded at the Standard Cost Categories (SCC) level of detail.

The costs are in 2015 dollars, adjusted locally to Philadelphia, PA and to size and scope of each alternative and option. In addition, the Cut & Cover Guideway and Station unit costs were adjusted manually to reflect project specific complexities for shoring of excavation (SOE) and ground improvements. All costs are based on the total linear miles of guideway, including necessary tail tracks.

Soft costs were added at 47% to account for Professional Services. Finally, a range of values was generated based on FTA guidelines of Probable Accuracy.

### ESTIMATES

The following table summarizes the anticipated project costs based on FTA Guidelines with allocated contingency:

| Alignment | Cost Category | Point Estimate | Estimate with Contingency |
|---|---|---|---|
| Rouse Boulevard | Construction (SCC 10-50) | $464M | $559M |
| | Soft (SCC 60-100) | $256M | $310M |
| | Total | $720M | $869M |
| 13th Street & Constitution Ave | Construction (SCC 10-50) | $806M | $972M |
| | Soft (SCC 60-100) | $439M | $531M |
| | Total | $1,225M | $1,503M |
| Broad Street & Kitty Hawk Ave | Construction (SCC 10-50) | $853M | $1,032M |
| | Soft (SCC 60-100) | $469M | $569M |
| | Total | $1,322M | $1,601M |

**Table 8. Order of Magnitude Cost Summary for each Alternative**

A detailed cost model for each estimate is provided as an attachment.

The BSLX cost estimates reported here are order of magnitude estimates for the purposes of determining the feasibility of the project. If the BSLX project is determined to be feasible, the cost estimates will be refined as the design is progressed further.

# VI. SUMMARY

In conjunction with the Steering Group, three alternative alignments for extending the Broad Street Line into the Navy Yard were developed. The number of stations serving the Navy Yard vary from 1 (Rouse Boulevard alignment) to 2 (both the 13th Street and Broad Street alignments). The FTA Capital Cost Database (CCD) was utilized to generate Order of Magnitude estimates for each alternative. Based on this approach, the total estimated cost was estimated at $869M for the Rouse Boulevard alignment (shortest) to $1,601M for the Broad Street alignment (longest). These estimates, in conjunction with the ridership forecasts, will be utilized to evaluate the cost effectiveness for each alternative.

# ATTACHMENT A

## CONCEPTUAL CAPITAL COST ESTIMATES

**Cost Model Compared With Project Estimate**

Cost Basis:
Reference Name:
Project City:
Mode:

# SEPTA Broad Street Extension
# Rouse Blvd Alternative 1

Philadelphia, PA
Light Rail Transit

Today's Date 1/18/2018
Base Year 2015

**Allocated Contingency Calculation**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0.00** | **TOTAL PROJECT COSTS** | **Lineal Miles of Guideway** | **1.0560** | | | **$681,541** | **$719,707** | | | **21%** | **$149,377** | **$869,084** | **$851,004** |
| | | Units | Quantity | Inlucde This Item (select 'Yes' or 'No') | Sample Size | Unit Cost ($) | Total Cost (a) ($000) | Base Year Dollars Percentage of Construction Cost | Base Year Dollars Percentage of Total Project Cost | Allocated Contingency (%) | Allocated Contingency($000) | Total Cost w/ Contingency (a) ($000) | Unit Cost w/ Contingency ($) |
| **10** | **Guideway & Track Elements** | **Lineal Miles of Guideway** | **1.056** | | **0** | **$200,306** | **$211,524** | **46%** | **29%** | **22%** | **$47,111** | **$258,634** | **$244,919** |
| 10.010 | Guideway: At-grade exclusive right-of-way | Lineal Miles of Guideway | | | 23 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.020 | Guideway: At-grade semi-exclusive (allows cross-traffic) | Lineal Miles of Guideway | | | 3 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.030 | Guideway: At-grade in mixed traffic | Lineal Miles of Guideway | | | 9 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.040 | Guideway: Aerial structure | Lineal Miles of Guideway | | | 25 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.050 | Guideway: Built-up fill | Lineal Miles of Guideway | | | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.060 | Guideway: Underground cut & cover | Lineal Miles of Guideway | 0.4775 | | 15 | $214,005,518 | $102,188 | | | 15% | 15,328 | 117,516 | 246,106,345 |
| 10.070 | Guideway: Underground tunnel | Lineal Miles of Guideway | 0.5785 | | 15 | $171,240,176 | $99,062 | | | 30% | 29,719 | 128,781 | 222,612,229 |
| 10.080 | Guideway: Retained cut or fill | Lineal Miles of Guideway | | | 11 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.090 | Track: Direct fixation | Track Miles | 1.056 | | 27 | $4,196,187 | $4,431 | | | 15% | 665 | 5,096 | 4,825,615 |
| 10.100 | Track: Embedded | Track Miles | | | 10 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.110 | Track: Ballasted | Track Miles | | | 24 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.120 | Track: Special (switches, turnouts) | Track Miles | 1.056 | Yes | 14 | $581,020 | $614 | | | 15% | 92 | 706 | 668,173 |
| 10.140 | Special Structures | Lineal Miles of Guideway | 1 | Yes | 3 | $4,951,459 | $5,229 | | | 25% | 1,307 | 6,536 | 6,189,324 |
| **20** | **Stations, Stops, Terminals, Intermodels** | **Stations** | **1** | | **0** | **$212,257** | **$212,257** | **46%** | **29%** | **18%** | **$38,133** | **$250,390** | **$250,390** |
| 20.010 | At-Grade Station, Stop, Shelter, Mall, Terminal, Platform | Stations | | | 25 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.020 | Aerial station, stop, shelter, mall, terminal, platform | Stations | | | 14 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.030 | Underground station, stop, shelter, mall, terminal, platform | Stations | 1 | | | $205,690 | $205,690 | | | | 37,148 | 242,838 | 242,838 |
| 20.031 | Cut and Cover | Stations | 1 | | 13 | $142,745,777 | $142,746 | | | 15% | 21,412 | 164,158 | 164,157,643 |
| 20.032 | Bored Earth Soft Soils | Stations | | | 1 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.033 | Bored Rock Hard Soils | Stations | | | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.034 | Unspecified (Fan Plant) | Stations | 1 | | 4 | $62,943,952 | $62,944 | | | 25% | 15,736 | 78,680 | 78,680 |
| 20.060 | Automobile parking multi-story structure | Spaces | | | 6 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.070 | Elevators, escalators | Number | 4 | | | $1,441 | $5,766 | | | | 865 | 6,631 | 1,657,720 |
| 20.071 | Elevators | Number | 2 | | 7 | $1,428,626 | $2,857 | | | 15% | 429 | 3,286 | 1,642,920 |
| 20.072 | Escalators | Number | 2 | | 8 | $1,454,365 | $2,909 | | | 15% | 436 | 3,345 | 1,672,520 |
| 20.080 | Passenger Overpass | Number | | | 7 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.090 | Underground Interconnecting Tunnel | Number | | No | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.100 | Signage and Graphics | Stations | 1 | | 18 | $801,401 | $801 | | | 15% | 120 | 922 | 921,611 |
| **30** | **Support Facilities: Yards, Shops, Admin. Bldgs** | **Vehicles** | **0** | | **0** | **$0** | **$0** | **0%** | **0%** | **0%** | **$0** | **$0** | **$0** |
| 30.010 | Administration Building: Office, sales, storage, revenue counting | Lineal Miles of Guideway | 1 | | | $0 | $0 | | | 0% | 0 | 0 | 0 |
| 30.011 | Administrative Building | Lineal Miles of Guideway | 0 | No | 7 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.012 | Central Control Facility | Lineal Miles of Guideway | 0 | No | 3 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.013 | Central Revenue Counting Facility | Lineal Miles of Guideway | 0 | No | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.020 | Light Maintenance Facility | Vehicles | 0 | No | 12 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.030 | Heavy Maintenance Facility | Vehicles | 0 | No | 21 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.040 | Storage or Maintenance of Way Building | Lineal Miles of Guideway | 0 | No | 8 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.050 | Yard and Yard Track | Track Miles | 0 | No | 9 | $0 | $0 | | | | 0 | 0 | 0 |
| **40** | **Sitework & Special Conditions** | **Lineal Miles of Guideway** | **1** | | **0** | **$21,015** | **$22,192** | **5%** | **3%** | **30%** | **$6,693** | **$28,885** | **$27,353** |
| 40.010 | Demolition, Clearing, Earthwork | Lineal Miles of Guideway | 1.056 | Yes | 20 | $5,047,298 | $5,330 | | | 35% | 1,865 | 7,195 | 6,813,853 |
| 40.020 | Site Utilities, Utility Relocation | Lineal Miles of Guideway | 1.056 | Yes | 94 | $5,822,996 | $6,149 | | | 35% | 2,152 | 8,301 | 7,861,044 |
| 40.030 | Haz. mat'l, contam'd soil removal/mitigation, ground water treatmen | Lineal Miles of Guideway | 1.056 | Yes | 7 | $1,656,165 | $1,749 | | | 20% | 350 | 2,099 | 1,987,398 |
| 40.040 | Environmental mitigation, e.g. wetlands, historic/archeologic, parks | Lineal Miles of Guideway | 1.056 | Yes | 14 | $1,798,574 | $1,899 | | | 20% | 380 | 2,279 | 2,158,288 |
| 40.050 | Site structures including retaining walls, sound walls | Lineal Miles of Guideway | 1.056 | Yes | 1 | $146,748 | $155 | | | 20% | 31 | 186 | 176,098 |
| 40.060 | Pedestrian / bike access and accommodation, landscaping | Lineal Miles of Guideway | 1.056 | Yes | 14 | $1,495,849 | $1,580 | | | 20% | 316 | 1,896 | 1,795,018 |
| 40.070 | Automobile, bus, van accessways including roads, parking lots | Spaces | 0 | | | $0 | $0 | | | 0% | 0 | 0 | 0 |
| 40.071 | Surface Parking Lot | Spaces | | | 12 | $0 | $0 | | | | 0 | 0 | 0 |
| 40.072 | Auto Access | Stations | | | 2 | $0 | $0 | | | | 0 | 0 | 0 |
| 40.080 | Temporary Facilities and other indirect costs during construction | Lineal Miles of Guideway | 1 | Yes | 34 | $5,047,310 | $5,330 | | | 30% | 1,599 | 6,929 | 6,561,503 |
| **50** | **Systems** | **Track Miles** | **1** | | **0** | **$17,019** | **$17,972** | **4%** | **2%** | **20%** | **$3,594** | **$21,566** | **$20,510** |
| 50.010 | Train control and signals | Track Miles | 1.056 | Yes | 38 | $4,737,574 | $5,003 | | | 20% | 1,001 | 6,003 | 5,685,089 |
| 50.020 | Traffic signals and crossing protection | Track Miles | 1.056 | Yes | 10 | $1,005,066 | $1,061 | | | 20% | 212 | 1,274 | 1,206,079 |
| 50.030 | Traction power supply: substations | Track Miles | 1.056 | Yes | 33 | $2,339,458 | $2,470 | | | 20% | 494 | 2,965 | 2,807,350 |
| 50.040 | Traction power distribution: catenary and third rail | Track Miles | 1.056 | | | $4,992 | $5,271 | | | | 1,054 | 6,325 | 5,990,012 |
| 50.041 | Catenary | Track Miles | 0 | Yes | 15 | $1,353,045 | $0 | | | | 0 | 0 | 0 |
| 50.042 | Third Rail | Track Miles | 1.056 | Yes | 14 | $4,587,705 | $4,845 | | | 20% | 969 | 5,814 | 5,505,246 |
| 50.043 | Power Distribution and Connections | Track Miles | 1.056 | Yes | 5 | $403,971 | $427 | | | 20% | 85 | 512 | 484,766 |
| 50.050 | Communications | Track Miles | 1.056 | Yes | 32 | $2,638,111 | $2,786 | | | 20% | 557 | 3,343 | 3,165,733 |
| 50.060 | Fare collection system and equipment | Stations | 1 | Yes | 36 | $1,380,091 | $1,380 | | | 20% | 276 | 1,656 | 1,656,109 |
| | **Construction Subtotal (10-50)** | **Lineal Miles of Guideway** | **1** | | **0** | **$439,341** | **$463,944** | **100%** | **64%** | **21%** | **$95,531** | **$559,476** | **$543,173** |
| **60** | **Row, Land, Existing Improvements** | **Lineal Miles of Guideway** | **1** | | **0** | **$25,380** | **$26,801** | | **4%** | **25%** | **$6,700** | **$33,501** | **$31,724** |
| 60.010 | Purchase or lease of real estate | Lineal Miles of Guideway | 1.056 | Yes | 35 | $18,960,323 | $20,022 | | | 25% | 5,006 | 25,028 | 23,700,404 |
| 60.020 | Relocation of existing households and businesses | Lineal Miles of Guideway | 1.056 | Yes | 18 | $4,697,446 | $4,961 | | | 25% | 1,240 | 6,201 | 5,871,807 |
| 60.030 | Services | Lineal Miles of Guideway | 1.056 | Yes | 34 | $1,721,778 | $1,818 | | | 25% | 455 | 2,273 | 2,152,223 |
| 60.040 | Other Real Estate Costs | Lineal Miles of Guideway | 0.000 | No | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| **70** | **Vehicles** | **Vehicles** | **0** | | **0** | **$0** | **$0** | | **0%** | **0%** | **$0** | **$0** | **$0** |
| 70.010 | Light Rail | Vehicles | | | 17 | $0 | $0 | | | | 0 | 0 | 0 |
| 70.020 | Heavy Rail | Vehicles | | | 11 | $0 | $0 | | | | 0 | 0 | 0 |
| 70.060 | Non-revenue vehicles | Vehicles | 0 | Yes | 17 | $0 | $0 | | | | 0 | 0 | 0 |
| **80** | **Professional Services** | **Hard Costs** | **$490,745.08** | | **0** | **47%** | **$228,962** | **0%** | **0%** | **21%** | **$47,146** | **$276,107** | **$276,107** |
| 80.010 | Preliminary Engineering | Hard Costs | $490,745.08 | Yes | 24 | 5% | $26,361 | | | 21% | 5,428 | 31,789 | 31,789,135 |
| 80.020 | Final Design | Hard Costs | $490,745.08 | Yes | 32 | 11% | $55,364 | | | 21% | 11,400 | 66,765 | 66,764,564 |
| 80.030 | Project Management for Design and Construction | Hard Costs | $490,745.08 | Yes | 50 | 10% | $48,977 | | | 21% | 10,085 | 59,062 | 59,062,101 |
| 80.040 | Construction Administration & Management | Hard Costs | $490,745.08 | Yes | 34 | 10% | $50,896 | | | 21% | 10,480 | 61,376 | 61,376,342 |
| 80.050 | Professional Liability and other Non-Construction Insurance | Hard Costs | $490,745.08 | Yes | 21 | 5% | $22,178 | | | 21% | 4,567 | 26,745 | 26,744,564 |
| 80.060 | Legal; Permits; Review Fees by other agencies, cities, etc. | Hard Costs | $490,745.08 | Yes | 7 | 2% | $10,604 | | | 21% | 2,184 | 12,788 | 12,787,674 |
| 80.070 | Surveys, Testing, Investigation, Inspection | Hard Costs | $490,745.08 | Yes | 3 | 0% | $1,504 | | | 21% | 310 | 1,813 | 1,813,439 |
| 80.080 | Start up | Hard Costs | $490,745.08 | Yes | 29 | 2% | $7,876 | | | 21% | 1,622 | 9,497 | 9,497,370 |
| 80.090 | Other | Hard Costs | $490,745.08 | Yes | 14 | 1% | $5,201 | | | 21% | 1,071 | 6,272 | 6,272,301 |
| | **Subtotal (10-80)** | **Lineal Miles of Guideway** | **1** | | **0** | **$681,541** | **$719,707** | | | **21%** | **149,377** | **869,084** | **851,004** |
| 90 | Unallocated Contingency | Total Amount | 1 | | 0 | $0 | $0 | | 0% | | 0 | 0 | 0 |
| | **Subtotal (10-90)** | **Lineal Miles of Guideway** | **1** | | **0** | **0** | **$719,707** | | **100%** | 21% | **149,377** | **869,084** | **851,004** |
| 100 | Finance Charges | Total Amount | 1 | | 0 | $0 | $0 | | 0% | | 0 | 0 | 0 |
| | **Total Project Costs (10-100)** | **Lineal Miles of Guideway** | **1** | | **0** | **$0** | **$719,707** | | **100%** | **21%** | **149,377** | **869,084** | **851,004** |

**Cost Model Compared With Project Estimate**

Cost Basis:
Reference Name:
Project City:
Mode:

# SEPTA Broad Street Extension
## 13th Street Alternative 2

Philadelphia, PA
Light Rail Transit

Today's Date 1/18/2018
Base Year 2015

**Allocated Contingency Calculation**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0.00** | **TOTAL PROJECT COSTS** | **Lineal Miles of Guideway** | **1.6875** | | | **$737,489** | **$1,244,513** | | | **21%** | **$258,879** | **$1,503,392** | **$1,038,577** |
| | | Units | Quantity | Inlucde This Item (select 'Yes' or 'No') | Sample Size | Unit Cost ($) | Total Cost (a) ($000) | Base Year Dollars Percentage of Construction Cost | Base Year Dollars Percentage of Total Project Cost | Allocated Contingency (%) | Allocated Contingency($000) | Total Cost w/ Contingency (a) ($000) | Unit Cost w/ Contingency ($0) |
| **10** | **Guideway & Track Elements** | **Lineal Miles of Guideway** | **1.6875** | | **0** | **$186,123** | **$314,083** | **39%** | **25%** | **23%** | **$73,226** | **$387,308** | **$229,516** |
| 10.010 | Guideway: At-grade exclusive right-of-way | Lineal Miles of Guideway | | | 23 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.020 | Guideway: At-grade semi-exclusive (allows cross-traffic) | Lineal Miles of Guideway | | | 3 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.030 | Guideway: At-grade in mixed traffic | Lineal Miles of Guideway | | | 9 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.040 | Guideway: Aerial structure | Lineal Miles of Guideway | | | 25 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.050 | Guideway: Built-up fill | Lineal Miles of Guideway | | | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.060 | Guideway: Underground cut & cover | Lineal Miles of Guideway | 0.7034 | | 15 | $183,605,346 | $129,148 | | | 15% | 19,372 | 148,520 | 211,146,148 |
| 10.070 | Guideway: Underground tunnel | Lineal Miles of Guideway | 0.9841 | | 15 | $171,240,176 | $168,517 | | | 30% | 50,555 | 219,073 | 222,612,229 |
| 10.080 | Guideway: Retained cut or fill | Lineal Miles of Guideway | | | 11 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.090 | Track: Direct fixation | Track Miles | 1.6875 | | 27 | $4,196,187 | $7,081 | | | 15% | 1,062 | 8,143 | 4,825,615 |
| 10.100 | Track: Embedded | Track Miles | | | 10 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.110 | Track: Ballasted | Track Miles | | | 24 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.120 | Track: Special (switches, turnouts) | Track Miles | 1.6875 | Yes | 14 | $581,020 | $980 | | | 15% | 147 | 1,128 | 668,173 |
| 10.140 | Special Structures | Lineal Miles of Guideway | 1.6875 | Yes | 3 | $4,951,459 | $8,356 | | | 25% | 2,089 | 10,444 | 6,189,324 |
| **20** | **Stations, Stops, Terminals, Intermodels** | **Stations** | **2** | | **0** | **$213,473** | **$426,946** | **53%** | **34%** | **18%** | **$76,631** | **$503,577** | **$251,788** |
| 20.010 | At-Grade Station, Stop, Shelter, Mall, Terminal, Platform | Stations | | | 25 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.020 | Aerial station, stop, shelter, mall, terminal, platform | Stations | | | 14 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.030 | Underground station, stop, shelter, mall, terminal, platform | Stations | 2 | | | $206,906 | $413,811 | | | | 74,661 | 488,472 | 244,236 |
| 20.031 | Cut and Cover | Stations | 2 | | 13 | $143,961,777 | $287,924 | | | 15% | 43,189 | 331,112 | 165,556,043 |
| 20.032 | Bored Earth Soft Soils | Stations | | | 1 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.033 | Bored Rock Hard Soils | Stations | | | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.034 | Unspecified (Fan Plant) | Stations | 2 | | 4 | $62,943,952 | $125,888 | | | 25% | 31,472 | 157,360 | 78,680 |
| 20.060 | Automobile parking multi-story structure | Spaces | | | 6 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.070 | Elevators, escalators | Number | 8 | | | $1,441 | $11,532 | | | | 1,730 | 13,262 | 1,657,720 |
| 20.071 | Elevators | Number | 4 | | 7 | $1,428,626 | $5,715 | | | 15% | 857 | 6,572 | 1,642,920 |
| 20.072 | Escalators | Number | 4 | | 8 | $1,454,365 | $5,817 | | | 15% | 873 | 6,690 | 1,672,520 |
| 20.080 | Passenger Overpass | Number | | | 7 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.090 | Underground Interconnecting Tunnel | Number | | No | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.100 | Signage and Graphics | Stations | 2 | | 18 | $801,401 | $1,603 | | | 15% | 240 | 1,843 | 921,611 |
| **30** | **Support Facilities: Yards, Shops, Admin. Bldgs** | **Vehicles** | **0** | | **0** | **$0** | **$0** | **0%** | **0%** | **0%** | **$0** | **$0** | **$0** |
| 30.010 | Administration Building: Office, sales, storage, revenue counting | Lineal Miles of Guideway | 1.6875 | | | $0 | $0 | | | 0% | 0 | 0 | 0 |
| 30.011 | Administrative Building | Lineal Miles of Guideway | 0 | No | 7 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.012 | Central Control Facility | Lineal Miles of Guideway | 0 | No | 3 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.013 | Central Revenue Counting Facility | Lineal Miles of Guideway | 0 | No | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.020 | Light Maintenance Facility | Vehicles | 0 | No | 12 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.030 | Heavy Maintenance Facility | Vehicles | 0 | No | 21 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.040 | Storage or Maintenance of Way Building | Lineal Miles of Guideway | 0 | No | 8 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.050 | Yard and Yard Track | Track Miles | 0 | No | 9 | $0 | $0 | | | | 0 | 0 | 0 |
| **40** | **Sitework & Special Conditions** | **Lineal Miles of Guideway** | **1.6875** | | **0** | **$21,015** | **$35,463** | **4%** | **3%** | **30%** | **$10,696** | **$46,159** | **$27,353** |
| 40.010 | Demolition, Clearing, Earthwork | Lineal Miles of Guideway | 1.6875 | Yes | 20 | $5,047,298 | $8,517 | | | 35% | 2,981 | 11,498 | 6,813,853 |
| 40.020 | Site Utilities, Utility Relocation | Lineal Miles of Guideway | 1.6875 | Yes | 94 | $5,822,996 | $9,826 | | | 35% | 3,439 | 13,266 | 7,861,044 |
| 40.030 | Haz. mat'l, contam'd soil removal/mitigation, ground water treatmer | Lineal Miles of Guideway | 1.6875 | Yes | 7 | $1,656,165 | $2,795 | | | 20% | 559 | 3,354 | 1,987,398 |
| 40.040 | Environmental mitigation, e.g. wetlands, historic/archeologic, parks | Lineal Miles of Guideway | 1.6875 | Yes | 14 | $1,798,574 | $3,035 | | | 20% | 607 | 3,642 | 2,158,288 |
| 40.050 | Site structures including retaining walls, sound walls | Lineal Miles of Guideway | 1.6875 | Yes | 1 | $146,748 | $248 | | | 20% | 50 | 297 | 176,098 |
| 40.060 | Pedestrian / bike access and accommodation, landscaping | Lineal Miles of Guideway | 1.6875 | Yes | 14 | $1,495,849 | $2,524 | | | 20% | 505 | 3,029 | 1,795,018 |
| 40.070 | Automobile, bus, van accessways including roads, parking lots | Spaces | 0 | | | $0 | $0 | | | 0% | 0 | 0 | 0 |
| 40.071 | Surface Parking Lot | Spaces | | | 12 | $0 | $0 | | | | 0 | 0 | 0 |
| 40.072 | Auto Access | Stations | | | 2 | $0 | $0 | | | | 0 | 0 | 0 |
| 40.080 | Temporary Facilities and other indirect costs during construction | Lineal Miles of Guideway | 2 | Yes | 34 | $5,047,310 | $8,517 | | | 30% | 2,555 | 11,073 | 6,561,503 |
| **50** | **Systems** | **Track Miles** | **1.6875** | | **0** | **$17,348** | **$29,274** | **4%** | **2%** | **20%** | **$5,855** | **$35,129** | **$20,510** |
| 50.010 | Train control and signals | Track Miles | 1.6875 | Yes | 38 | $4,737,574 | $7,995 | | | 20% | 1,599 | 9,594 | 5,685,089 |
| 50.020 | Traffic signals and crossing protection | Track Miles | 1.6875 | Yes | 10 | $1,005,066 | $1,696 | | | 20% | 339 | 2,035 | 1,206,079 |
| 50.030 | Traction power supply: substations | Track Miles | 1.6875 | Yes | 33 | $2,339,458 | $3,948 | | | 20% | 790 | 4,737 | 2,807,350 |
| 50.040 | Traction power distribution: catenary and third rail | Track Miles | 1.6875 | | | $4,992 | $8,423 | | | | 1,685 | 10,108 | 5,990,012 |
| 50.041 | Catenary | Track Miles | 0 | Yes | 15 | $1,353,045 | $0 | | | | 0 | 0 | 0 |
| 50.042 | Third Rail | Track Miles | 1.6875 | Yes | 14 | $4,587,705 | $7,742 | | | 20% | 1,548 | 9,290 | 5,505,246 |
| 50.043 | Power Distribution and Connections | Track Miles | 1.6875 | Yes | 5 | $403,971 | $682 | | | 20% | 136 | 818 | 484,766 |
| 50.050 | Communications | Track Miles | 1.6875 | Yes | 32 | $2,638,111 | $4,452 | | | 20% | 890 | 5,342 | 3,165,733 |
| 50.060 | Fare collection system and equipment | Stations | 2.000 | Yes | 36 | $1,380,091 | $2,760 | | | 20% | 552 | 3,312 | 1,656,109 |
| | **Construction Subtotal (10-50)** | **Lineal Miles of Guideway** | **1.6875** | | **0** | **$477,491** | **$805,766** | **100%** | **65%** | **21%** | **$166,407** | **$972,172** | **$529,168** |
| **60** | **Row, Land, Existing Improvements** | **Lineal Miles of Guideway** | **1.6875** | | **0** | **$25,380** | **$42,828** | | **3%** | **25%** | **$10,707** | **$53,535** | **$31,724** |
| 60.010 | Purchase or lease of real estate | Lineal Miles of Guideway | 1.6875 | Yes | 35 | $18,960,323 | $31,996 | | | 25% | 7,999 | 39,994 | 23,700,404 |
| 60.020 | Relocation of existing households and businesses | Lineal Miles of Guideway | 1.6875 | Yes | 18 | $4,697,446 | $7,927 | | | 25% | 1,982 | 9,909 | 5,871,807 |
| 60.030 | Services | Lineal Miles of Guideway | 1.6875 | Yes | 34 | $1,721,778 | $2,906 | | | 25% | 726 | 3,632 | 2,152,223 |
| 60.040 | Other Real Estate Costs | Lineal Miles of Guideway | 0.0000 | No | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| **70** | **Vehicles** | **Vehicles** | **0** | | **0** | **$0** | **$0** | | **0%** | **0%** | **$0** | **$0** | **$0** |
| 70.010 | Light Rail | Vehicles | | | 17 | $0 | $0 | | | | 0 | 0 | 0 |
| 70.020 | Heavy Rail | Vehicles | | | 11 | $0 | $0 | | | | 0 | 0 | 0 |
| 70.060 | Non-revenue vehicles | Vehicles | 0 | Yes | 17 | $0 | $0 | | | | 0 | 0 | 0 |
| **80** | **Professional Services** | **Hard Costs** | **$848,593.49** | | **0** | **47%** | **$395,919** | **0%** | **0%** | **21%** | **$81,765** | **$477,685** | **$477,685** |
| 80.010 | Preliminary Engineering | Hard Costs | $848,593.49 | Yes | 24 | 5% | $45,583 | | | 21% | 9,414 | 54,997 | 54,997,349 |
| 80.020 | Final Design | Hard Costs | $848,593.49 | Yes | 32 | 11% | $95,736 | | | 21% | 19,771 | 115,507 | 115,507,201 |
| 80.030 | Project Management for Design and Construction | Hard Costs | $848,593.49 | Yes | 50 | 10% | $84,691 | | | 21% | 17,490 | 102,181 | 102,181,420 |
| 80.040 | Construction Administration & Management | Hard Costs | $848,593.49 | Yes | 34 | 10% | $88,009 | | | 21% | 18,176 | 106,185 | 106,185,213 |
| 80.050 | Professional Liability and other Non-Construction Insurance | Hard Costs | $848,593.49 | Yes | 21 | 5% | $38,350 | | | 21% | 7,920 | 46,270 | 46,269,901 |
| 80.060 | Legal; Permits; Review Fees by other agencies, cities, etc. | Hard Costs | $848,593.49 | Yes | 7 | 2% | $18,337 | | | 21% | 3,787 | 22,124 | 22,123,539 |
| 80.070 | Surveys, Testing, Investigation, Inspection | Hard Costs | $848,593.49 | Yes | 3 | 0% | $2,600 | | | 21% | 537 | 3,137 | 3,137,371 |
| 80.080 | Start up | Hard Costs | $848,593.49 | Yes | 29 | 2% | $13,619 | | | 21% | 2,813 | 16,431 | 16,431,091 |
| 80.090 | Other | Hard Costs | $848,593.49 | Yes | 14 | 1% | $8,994 | | | 21% | 1,857 | 10,852 | 10,851,504 |
| | **Subtotal (10-80)** | **Lineal Miles of Guideway** | **1.6875** | | **0** | **$737,489** | **$1,244,513** | | | **21%** | **258,879** | **1,503,392** | **1,038,577** |
| 90 | Unallocated Contingency | Total Amount | 1.6875 | | 0 | $0 | $0 | | 0% | | 0 | 0 | 0 |
| | **Subtotal (10-90)** | **Lineal Miles of Guideway** | **1.6875** | | **0** | **0** | **$1,244,513** | | **100%** | 21% | **258,879** | **1,503,392** | **1,038,577** |
| 100 | Finance Charges | Total Amount | 1.6875 | | 0 | $0 | $0 | | 0% | | 0 | 0 | 0 |
| | **Total Project Costs (10-100)** | **Lineal Miles of Guideway** | **1.6875** | | **0** | **$0** | **$1,244,513** | | **100%** | **21%** | **258,879** | **1,503,392** | **1,038,577** |

**Cost Model Compared With Project Estimate**

Cost Basis:
Reference Name:
Project City:
Mode:

# SEPTA Broad Street Extension
# Broad Street Alternative 3

Philadelphia, PA
Light Rail Transit

Today's Date 1/18/2018
Base Year 2015

**Allocated Contingency Calculation**

| | | Units | Quantity | Inlucde This Item (select 'Yes' or 'No') | Sample Size | Unit Cost ($) | Total Cost (a) ($000) | Base Year Dollars Percentage of Construction Cost | Base Year Dollars Percentage of Total Project Cost | Allocated Contingency (%) | Allocated Contingency($000) | Total Cost w/ Contingency (a) ($000) | Unit Cost w/ Contingency ($0) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0.00** | **TOTAL PROJECT COSTS** | **Lineal Miles of Guideway** | **1.91** | | | **$693,139** | **$1,321,885** | | | **21%** | **$278,842** | **$1,600,727** | **$1,068,926** |
| **10** | **Guideway & Track Elements** | **Lineal Miles of Guideway** | **1.9071** | | **0** | **$185,207** | **$353,209** | **41%** | **27%** | **24%** | **$83,395** | **$436,604** | **$228,936** |
| 10.010 | Guideway: At-grade exclusive right-of-way | Lineal Miles of Guideway | | | 23 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.020 | Guideway: At-grade semi-exclusive (allows cross-traffic) | Lineal Miles of Guideway | | | 3 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.030 | Guideway: At-grade in mixed traffic | Lineal Miles of Guideway | | | 9 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.040 | Guideway: Aerial structure | Lineal Miles of Guideway | | | 25 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.050 | Guideway: Built-up fill | Lineal Miles of Guideway | | | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.060 | Guideway: Underground cut & cover | Lineal Miles of Guideway | 0.7598 | | 15 | $181,878,686 | $138,191 | | | 15% | 20,729 | 158,920 | 209,160,488 |
| 10.070 | Guideway: Underground tunnel | Lineal Miles of Guideway | 1.1473 | | 15 | $171,240,176 | $196,464 | | | 30% | 58,939 | 255,403 | 222,612,229 |
| 10.080 | Guideway: Retained cut or fill | Lineal Miles of Guideway | | | 11 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.090 | Track: Direct fixation | Track Miles | 1.9071 | | 27 | $4,196,187 | $8,003 | | | 15% | 1,200 | 9,203 | 4,825,615 |
| 10.100 | Track: Embedded | Track Miles | | | 10 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.110 | Track: Ballasted | Track Miles | | | 24 | $0 | $0 | | | | 0 | 0 | 0 |
| 10.120 | Track: Special (switches, turnouts) | Track Miles | 1.9071 | Yes | 14 | $581,020 | $1,108 | | | 15% | 166 | 1,274 | 668,173 |
| 10.140 | Special Structures | Lineal Miles of Guideway | 1.9071 | Yes | 3 | $4,951,459 | $9,443 | | | 25% | 2,361 | 11,804 | 6,189,324 |
| **20** | **Stations, Stops, Terminals, Intermodels** | **Stations** | **2** | | **0** | **$213,469** | **$426,939** | **50%** | **32%** | **18%** | **$76,630** | **$503,569** | **$251,784** |
| 20.010 | At-Grade Station, Stop, Shelter, Mall, Terminal, Platform | Stations | | | 25 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.020 | Aerial station, stop, shelter, mall, terminal, platform | Stations | | | 14 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.030 | Underground station, stop, shelter, mall, terminal, platform | Stations | 2 | | | $206,902 | $413,804 | | | | 74,659 | 488,464 | 244,232 |
| 20.031 | Cut and Cover | Stations | 2 | | 13 | $143,958,152 | $287,916 | | | 15% | 43,187 | 331,104 | 165,551,874 |
| 20.032 | Bored Earth Soft Soils | Stations | | | 1 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.033 | Bored Rock Hard Soils | Stations | | | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.034 | Unspecified (Fan Plant) | Stations | 2 | | 4 | $62,943,952 | $125,888 | | | 25% | 31,472 | 157,360 | 78,680 |
| 20.060 | Automobile parking multi-story structure | Spaces | | | 6 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.070 | Elevators, escalators | Number | 8 | | | $1,441 | $11,532 | | | | 1,730 | 13,262 | 1,657,720 |
| 20.071 | Elevators | Number | 4 | | 7 | $1,428,626 | $5,715 | | | 15% | 857 | 6,572 | 1,642,920 |
| 20.072 | Escalators | Number | 4 | | 8 | $1,454,365 | $5,817 | | | 15% | 873 | 6,690 | 1,672,520 |
| 20.080 | Passenger Overpass | Number | | | 7 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.090 | Underground Interconnecting Tunnel | Number | | No | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 20.100 | Signage and Graphics | Stations | 2 | | 18 | $801,401 | $1,603 | | | 15% | 240 | 1,843 | 921,611 |
| **30** | **Support Facilities: Yards, Shops, Admin. Bldgs** | **Vehicles** | **0** | | **0** | **$0** | **$0** | **0%** | **0%** | **0%** | **$0** | **$0** | **$0** |
| 30.010 | Administration Building: Office, sales, storage, revenue counting | Lineal Miles of Guideway | 2 | | | $0 | $0 | | | 0% | 0 | 0 | 0 |
| 30.011 | Administrative Building | Lineal Miles of Guideway | 0 | No | 7 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.012 | Central Control Facility | Lineal Miles of Guideway | 0 | No | 3 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.013 | Central Revenue Counting Facility | Lineal Miles of Guideway | 0 | No | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.020 | Light Maintenance Facility | Vehicles | 0 | No | 12 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.030 | Heavy Maintenance Facility | Vehicles | 0 | No | 21 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.040 | Storage or Maintenance of Way Building | Lineal Miles of Guideway | 0 | No | 8 | $0 | $0 | | | | 0 | 0 | 0 |
| 30.050 | Yard and Yard Track | Track Miles | 0 | No | 9 | $0 | $0 | | | | 0 | 0 | 0 |
| **40** | **Sitework & Special Conditions** | **Lineal Miles of Guideway** | **2** | | **0** | **$21,015** | **$40,078** | **5%** | **3%** | **30%** | **$12,088** | **$52,165** | **$27,353** |
| 40.010 | Demolition, Clearing, Earthwork | Lineal Miles of Guideway | 2 | Yes | 20 | $5,047,298 | $9,626 | | | 35% | 3,369 | 12,995 | 6,813,853 |
| 40.020 | Site Utilities, Utility Relocation | Lineal Miles of Guideway | 2 | Yes | 94 | $5,822,996 | $11,105 | | | 35% | 3,887 | 14,992 | 7,861,044 |
| 40.030 | Haz. mat'l, contam'd soil removal/mitigation, ground water treatmer | Lineal Miles of Guideway | 2 | Yes | 7 | $1,656,165 | $3,158 | | | 20% | 632 | 3,790 | 1,987,398 |
| 40.040 | Environmental mitigation, e.g. wetlands, historic/archeologic, parks | Lineal Miles of Guideway | 2 | Yes | 14 | $1,798,574 | $3,430 | | | 20% | 686 | 4,116 | 2,158,288 |
| 40.050 | Site structures including retaining walls, sound walls | Lineal Miles of Guideway | 2 | Yes | 1 | $146,748 | $280 | | | 20% | 56 | 336 | 176,098 |
| 40.060 | Pedestrian / bike access and accommodation, landscaping | Lineal Miles of Guideway | 2 | Yes | 14 | $1,495,849 | $2,853 | | | 20% | 571 | 3,423 | 1,795,018 |
| 40.070 | Automobile, bus, van accessways including roads, parking lots | Spaces | 0 | | | $0 | $0 | | | 0% | 0 | 0 | 0 |
| 40.071 | Surface Parking Lot | Spaces | | | 12 | $0 | $0 | | | | 0 | 0 | 0 |
| 40.072 | Auto Access | Stations | | | 2 | $0 | $0 | | | | 0 | 0 | 0 |
| 40.080 | Temporary Facilities and other indirect costs during construction | Lineal Miles of Guideway | 1.9071 | Yes | 34 | $5,047,310 | $9,626 | | | 30% | 2,888 | 12,513 | 6,561,503 |
| **50** | **Systems** | **Track Miles** | **1.9071** | | **0** | **$17,159** | **$32,724** | **4%** | **2%** | **20%** | **$6,545** | **$39,269** | **$20,510** |
| 50.010 | Train control and signals | Track Miles | 1.9071 | Yes | 38 | $4,737,574 | $9,035 | | | 20% | 1,807 | 10,842 | 5,685,089 |
| 50.020 | Traffic signals and crossing protection | Track Miles | 1.9071 | Yes | 10 | $1,005,066 | $1,917 | | | 20% | 383 | 2,300 | 1,206,079 |
| 50.030 | Traction power supply: substations | Track Miles | 1.9071 | Yes | 33 | $2,339,458 | $4,462 | | | 20% | 892 | 5,354 | 2,807,350 |
| 50.040 | Traction power distribution: catenary and third rail | Track Miles | 1.9071 | | | $4,992 | $9,520 | | | | 1,904 | 11,424 | 5,990,012 |
| 50.041 | Catenary | Track Miles | 0 | Yes | 15 | $1,353,045 | $0 | | | | 0 | 0 | 0 |
| 50.042 | Third Rail | Track Miles | 1.9071 | Yes | 14 | $4,587,705 | $8,749 | | | 20% | 1,750 | 10,499 | 5,505,246 |
| 50.043 | Power Distribution and Connections | Track Miles | 1.9071 | Yes | 5 | $403,971 | $770 | | | 20% | 154 | 924 | 484,766 |
| 50.050 | Communications | Track Miles | 1.9071 | Yes | 32 | $2,638,111 | $5,031 | | | 20% | 1,006 | 6,037 | 3,165,733 |
| 50.060 | Fare collection system and equipment | Stations | 2.0000 | Yes | 36 | $1,380,091 | $2,760 | | | 20% | 552 | 3,312 | 1,656,109 |
| | **Construction Subtotal (10-50)** | **Lineal Miles of Guideway** | **1.9071** | | **0** | **$447,250** | **$852,950** | **100%** | **65%** | **21%** | **$178,657** | **$1,031,607** | **$528,584** |
| **60** | **Row, Land, Existing Improvements** | **Lineal Miles of Guideway** | **1.9071** | | **0** | **$25,380** | **$48,401** | | **4%** | **25%** | **$12,100** | **$60,502** | **$31,724** |
| 60.010 | Purchase or lease of real estate | Lineal Miles of Guideway | 1.9071 | Yes | 35 | $18,960,323 | $36,159 | | | 25% | 9,040 | 45,199 | 23,700,404 |
| 60.020 | Relocation of existing households and businesses | Lineal Miles of Guideway | 1.9071 | Yes | 18 | $4,697,446 | $8,958 | | | 25% | 2,240 | 11,198 | 5,871,807 |
| 60.030 | Services | Lineal Miles of Guideway | 1.9071 | Yes | 34 | $1,721,778 | $3,284 | | | 25% | 821 | 4,105 | 2,152,223 |
| 60.040 | Other Real Estate Costs | Lineal Miles of Guideway | 1.9071 | Yes | 0 | $0 | $0 | | | | 0 | 0 | 0 |
| **70** | **Vehicles** | **Vehicles** | **0** | | **0** | **$0** | **$0** | | **0%** | **0%** | **$0** | **$0** | **$0** |
| 70.010 | Light Rail | Vehicles | | | 17 | $0 | $0 | | | | 0 | 0 | 0 |
| 70.020 | Heavy Rail | Vehicles | | | 11 | $0 | $0 | | | | 0 | 0 | 0 |
| 70.060 | Non-revenue vehicles | Vehicles | 0 | Yes | 17 | $0 | $0 | | | | 0 | 0 | 0 |
| **80** | **Professional Services** | **Hard Costs** | **$901,351.04** | | **0** | **47%** | **$420,534** | **0%** | **0%** | **21%** | **$88,084** | **$508,618** | **$508,618** |
| 80.010 | Preliminary Engineering | Hard Costs | $901,351.04 | Yes | 24 | 5% | $48,417 | | | 21% | 10,141 | 58,559 | 58,558,818 |
| 80.020 | Final Design | Hard Costs | $901,351.04 | Yes | 32 | 11% | $101,688 | | | 21% | 21,299 | 122,987 | 122,987,112 |
| 80.030 | Project Management for Design and Construction | Hard Costs | $901,351.04 | Yes | 50 | 10% | $89,956 | | | 21% | 18,842 | 108,798 | 108,798,393 |
| 80.040 | Construction Administration & Management | Hard Costs | $901,351.04 | Yes | 34 | 10% | $93,481 | | | 21% | 19,580 | 113,061 | 113,061,460 |
| 80.050 | Professional Liability and other Non-Construction Insurance | Hard Costs | $901,351.04 | Yes | 21 | 5% | $40,734 | | | 21% | 8,532 | 49,266 | 49,266,206 |
| 80.060 | Legal; Permits; Review Fees by other agencies, cities, etc. | Hard Costs | $901,351.04 | Yes | 7 | 2% | $19,477 | | | 21% | 4,080 | 23,556 | 23,556,195 |
| 80.070 | Surveys, Testing, Investigation, Inspection | Hard Costs | $901,351.04 | Yes | 3 | 0% | $2,762 | | | 21% | 579 | 3,341 | 3,340,538 |
| 80.080 | Start up | Hard Costs | $901,351.04 | Yes | 29 | 2% | $14,465 | | | 21% | 3,030 | 17,495 | 17,495,120 |
| 80.090 | Other | Hard Costs | $901,351.04 | Yes | 14 | 1% | $9,553 | | | 21% | 2,001 | 11,554 | 11,554,216 |
| | **Subtotal (10-80)** | **Lineal Miles of Guideway** | **2** | | **0** | **$693,139** | **$1,321,885** | | | **21%** | **278,842** | **1,600,727** | **1,068,926** |
| 90 | Unallocated Contingency | Total Amount | 2 | | 0 | $0 | $0 | | 0% | | 0 | 0 | 0 |
| | **Subtotal (10-90)** | **Lineal Miles of Guideway** | **2** | | **0** | **0** | **$1,321,885** | | **100%** | 21% | **278,842** | **1,600,727** | **1,068,926** |
| 100 | Finance Charges | Total Amount | 2 | | 0 | $0 | $0 | | 0% | | 0 | 0 | 0 |
| | **Total Project Costs (10-100)** | **Lineal Miles of Guideway** | **2** | | **0** | **$0** | **$1,321,885** | | **100%** | **21%** | **278,842** | **1,600,727** | **1,068,926** |

# ATTACHMENT B

## CONCEPTUAL PLANS

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# SEPTA BROAD STREET LINE EXTENSION TO THE PHILADELPHIA NAVY YARD

BSLX NAVY YARD

## CONCEPTUAL PLAN

SEPTA PROJECT NO.:

FTA NO.:

PENNDOT PROJECT NO.: E03137-WO#8

### LIST OF DRAWINGS

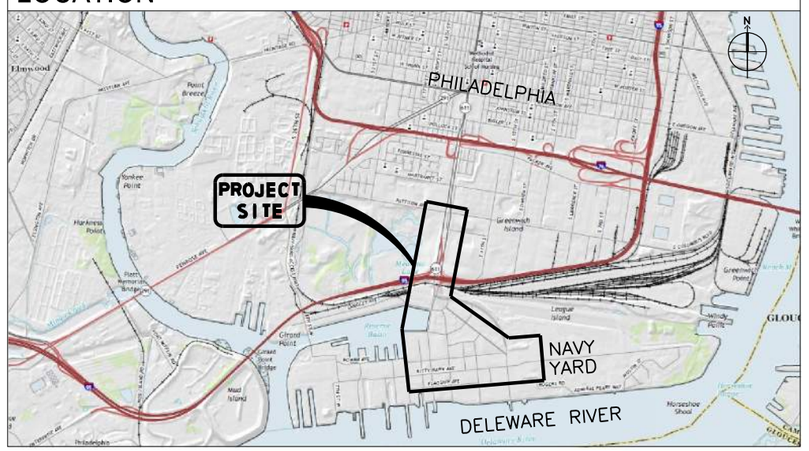
| SHEET NUMBER | DRAWING NUMBER | DRAWING TITLE |
|---|---|---|
| 1 | T-000 | COVER SHEET |
| 2 | T-100 | STADIUM DISTRICT PLAN AND PROFILE |
| 3 | T-101 | NAVY YARD – ROUSE BLVD ALTERNATE PLAN AND PROFILE |
| 4 | T-102 | NAVY YARD – 13TH STREET ALTERNATE PLAN AND PROFILE |
| 5 | T-103 | NAVY YARD – BROAD STREET ALTERNATE PLAN AND PROFILE |
| 6 | T-700 | STADIUM DISTRICT TYPICAL SECTIONS |
| 7 | T-701 | NAVY YARD – ROUSE BLVD ALTERNATE TYPICAL SECTIONS |
| 8 | T-702 | NAVY YARD – 13TH STREET ALTERNATE TYPICAL SECTIONS |
| 9 | T-703 | NAVY YARD – 13TH ST/BROAD ST ALTERNATE TYPICAL SECTIONS |
| 10 | T-704 | NAVY YARD – BROAD STREET ALTERNATE TYPICAL SECTIONS |
| 11 | T-705 | NAVY YARD – BROAD STREET ALTERNATE TYPICAL SECTIONS |

### ACT NO. NOTIFICATION LIST

### ACT NO. NOTIFICATION LIST

### CONTACT PHONE LIST

### LOCATION




CHIEF ENGINEER - EMSC
CHIEF ENGINEERING OFFICER - BSB
CHIEF FAIL TRANSIT OFFICER
SYSTEM SAFETY
DIRECTOR OF ENGINEERING - BSB
MANAGER - ARCH / ENGINEERING
PROJECT MANAGER


HNTB
HNTB Corporation
1650 Arch Street
Suite 1700
Philadelphia, PA 19103
215-568-6500


| REV | DATE | DESCRIPTION | BY | CKD | APD |
|---|---|---|---|---|---|

61353-s-rr-cov000.dgn

**PHILADELPHIA NAVY YARD**
BROAD STREET LINE EXTENSION
**RAIL**
**CONCEPTUAL PLAN**
**TRACK**
COVER SHEET

| SCALE: | SCALE FACTOR: |
|---|---|
| NONE | NONE |
| DATE: 11/14/2016 | DRAWN BY: DP |
| WORK ORDER NO.: | CHECKED BY: BDH |

SHEET NUMBER
**T-000**

DWG. NO.: 1 OF 11
SHT. NO.: 1 OF 11
ARCHIVE NO.:

COMPUTER FILE NO.: 61353-s-rr-cov000
REV. NO.:

DATE PRINTED: 11/11/2016

STATUS

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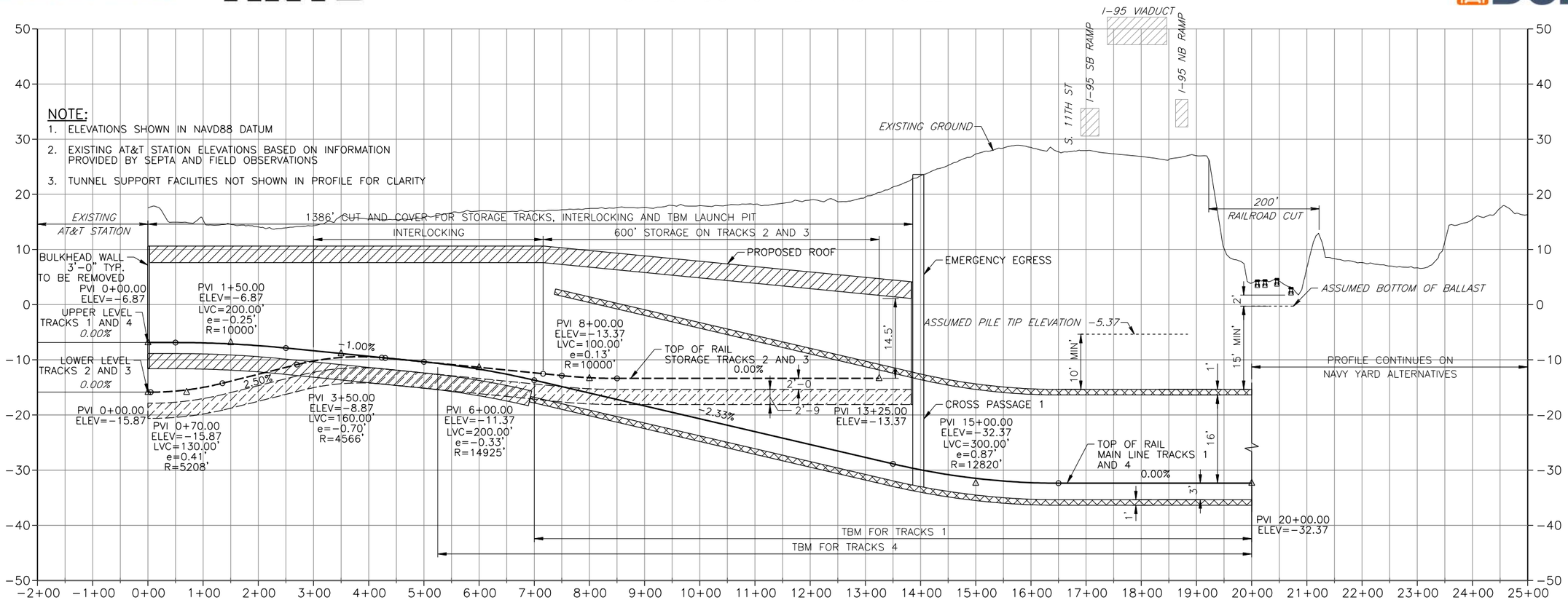
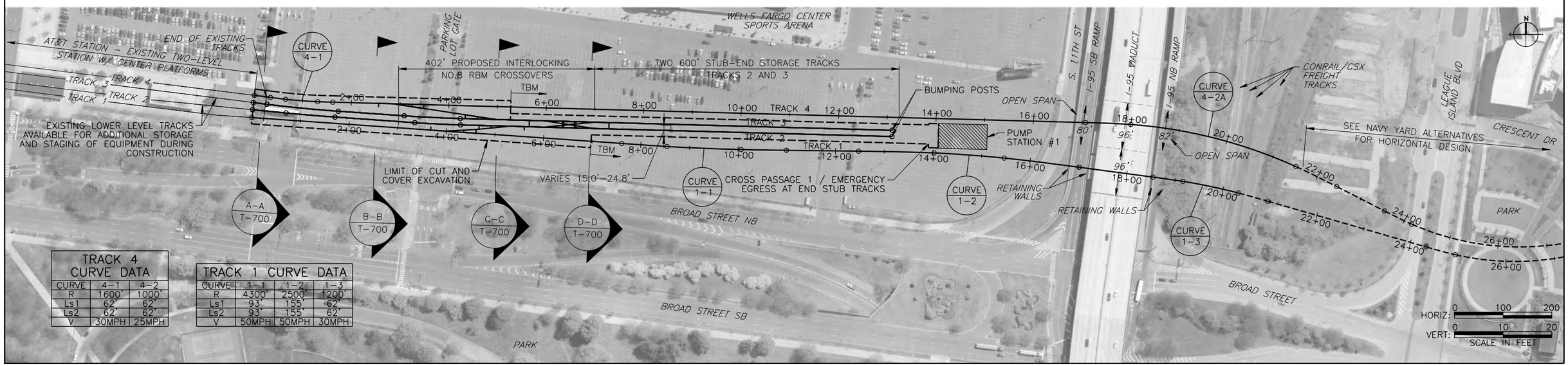
HNTB

# SEPTA BROAD STREET LINE EXTENSION
## STADIUM DISTRICT PLAN AND PROFILE

NOVEMBER 14, 2016

BSLX NAVY YARD




| TRACK 4 CURVE DATA | | |
|---|---|---|
| CURVE | 4-1 | 4-2 |
| R | 1600' | 1000' |
| Ls1 | 62' | 62' |
| Ls2 | 62' | 62' |
| V | 30MPH | 25MPH |

| TRACK 1 CURVE DATA | | | |
|---|---|---|---|
| CURVE | 1-1 | 1-2 | 1-3 |
| R | 4300' | 2500' | 1200' |
| Ls1 | 93' | 155' | 62' |
| Ls2 | 93' | 155' | 62' |
| V | 50MPH | 50MPH | 30MPH |

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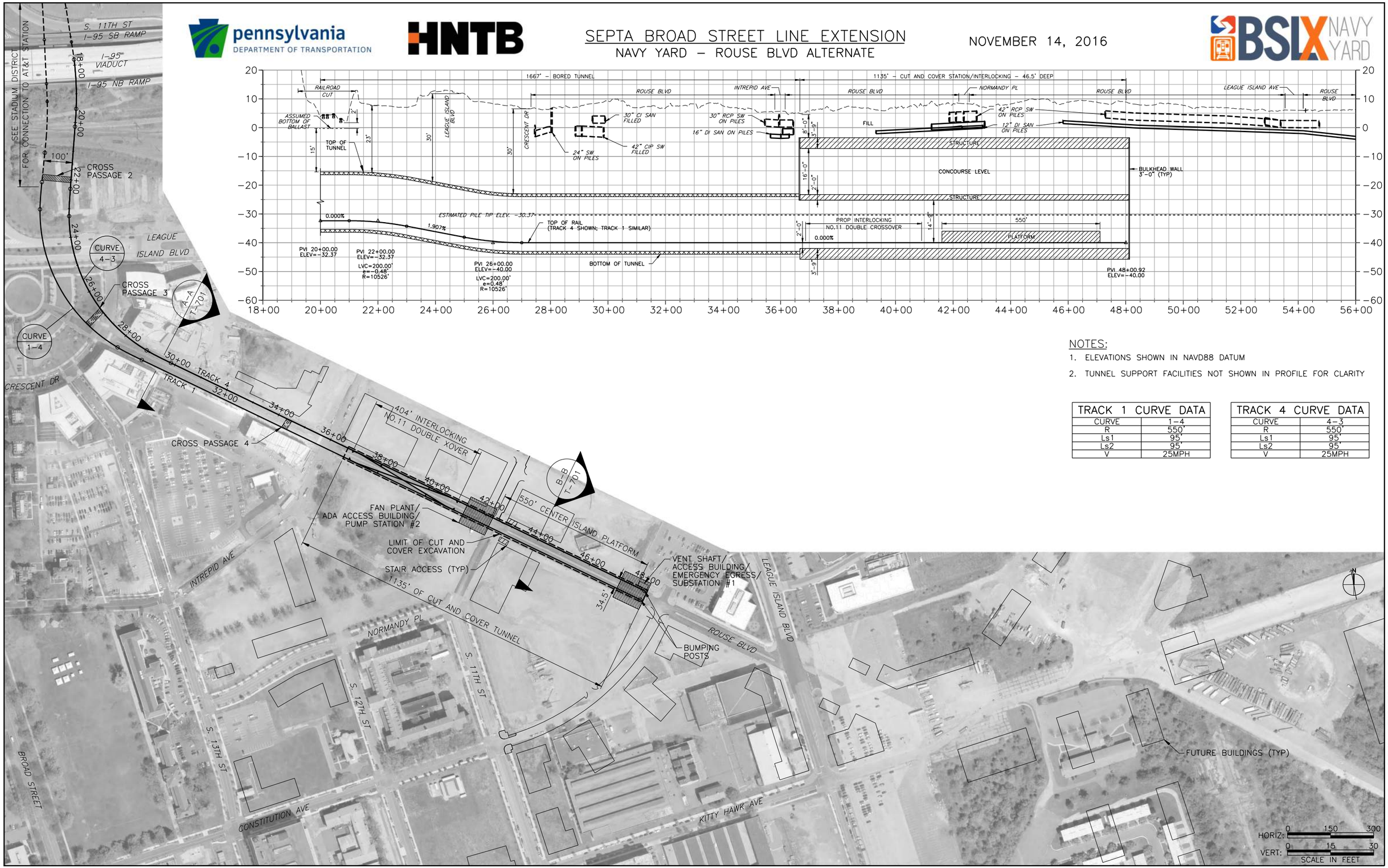
# SEPTA BROAD STREET LINE EXTENSION
## NAVY YARD – ROUSE BLVD ALTERNATE

NOVEMBER 14, 2016

BSLX NAVY YARD




NOTES:

1. ELEVATIONS SHOWN IN NAVD88 DATUM
2. TUNNEL SUPPORT FACILITIES NOT SHOWN IN PROFILE FOR CLARITY

| TRACK 1 CURVE DATA | |
|---|---|
| CURVE | 1–4 |
| R | 550' |
| Ls1 | 95' |
| Ls2 | 95' |
| V | 25MPH |

| TRACK 4 CURVE DATA | |
|---|---|
| CURVE | 4–3 |
| R | 550' |
| Ls1 | 95' |
| Ls2 | 95' |
| V | 25MPH |

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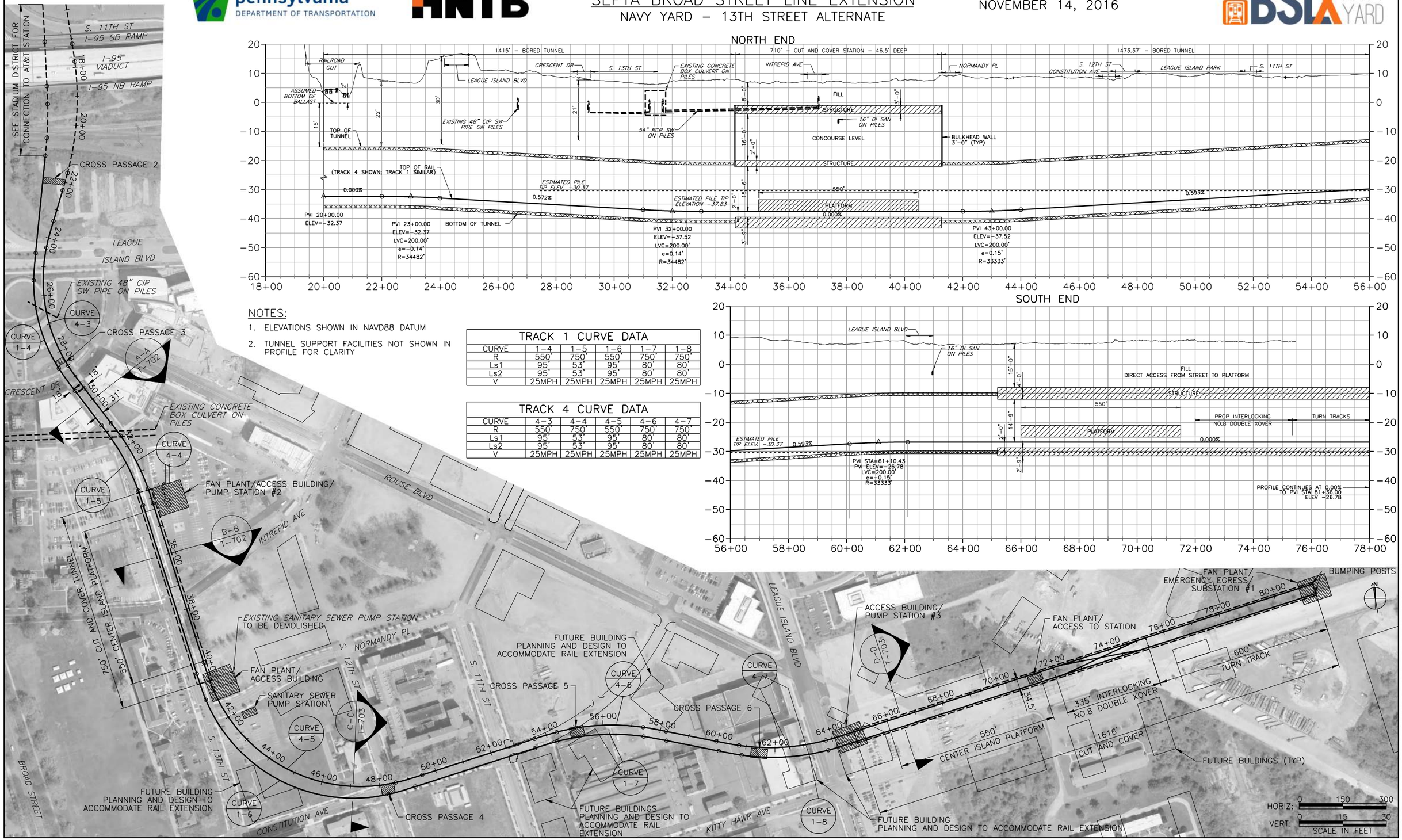
# SEPTA BROAD STREET LINE EXTENSION
## NAVY YARD – 13TH STREET ALTERNATE

NOVEMBER 14, 2016

BSLX NAVY YARD




NOTES:

1. ELEVATIONS SHOWN IN NAVD88 DATUM
2. TUNNEL SUPPORT FACILITIES NOT SHOWN IN PROFILE FOR CLARITY

| TRACK 1 CURVE DATA | | | | | |
|---|---|---|---|---|---|
| CURVE | 1–4 | 1–5 | 1–6 | 1–7 | 1–8 |
| R | 550' | 750' | 550' | 750' | 750' |
| Ls1 | 95' | 53' | 95' | 80' | 80' |
| Ls2 | 95' | 53' | 95' | 80' | 80' |
| V | 25MPH | 25MPH | 25MPH | 25MPH | 25MPH |

| TRACK 4 CURVE DATA | | | | | |
|---|---|---|---|---|---|
| CURVE | 4–3 | 4–4 | 4–5 | 4–6 | 4–7 |
| R | 550' | 750' | 550' | 750' | 750' |
| Ls1 | 95' | 53' | 95' | 80' | 80' |
| Ls2 | 95' | 53' | 95' | 80' | 80' |
| V | 25MPH | 25MPH | 25MPH | 25MPH | 25MPH |

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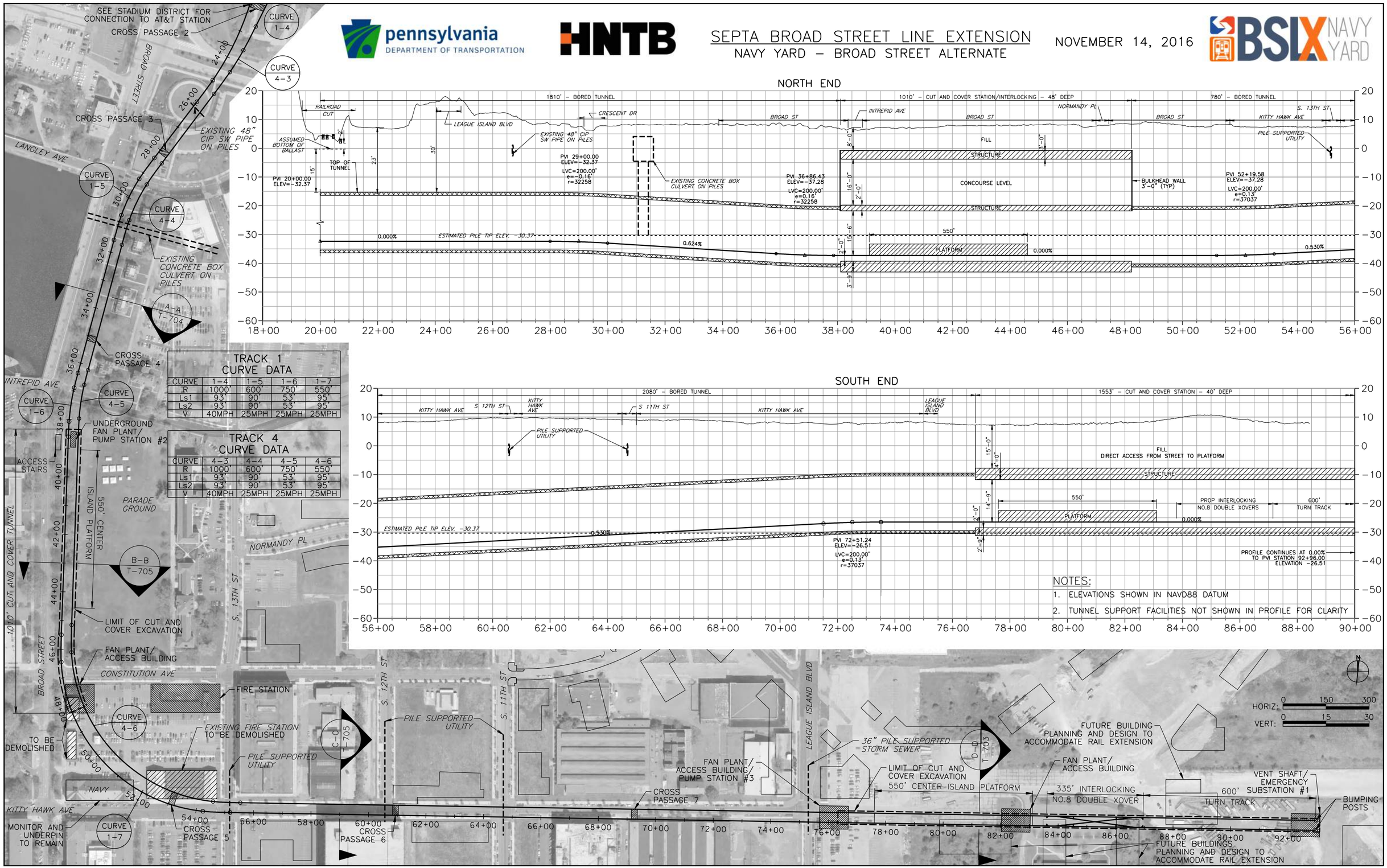
# SEPTA BROAD STREET LINE EXTENSION
## NAVY YARD – BROAD STREET ALTERNATE

NOVEMBER 14, 2016

BSLX NAVY YARD

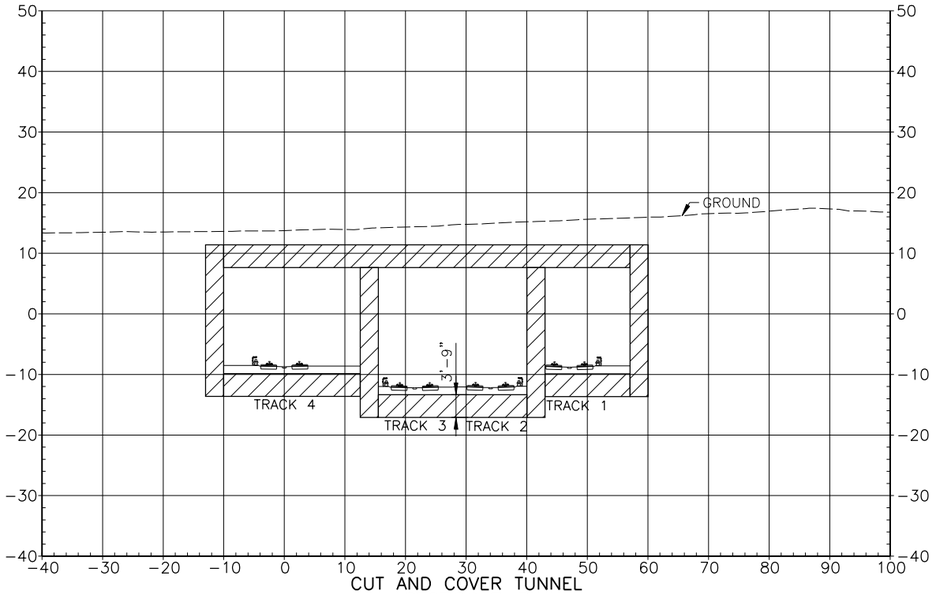



### TRACK 1 CURVE DATA

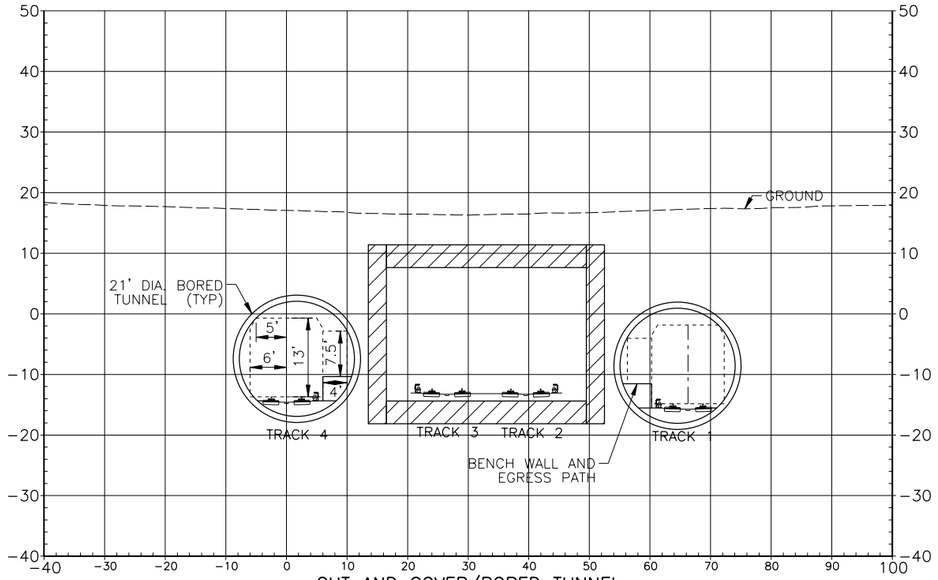
| CURVE | 1–4 | 1–5 | 1–6 | 1–7 |
|---|---|---|---|---|
| R | 1000' | 600' | 750' | 550' |
| Ls1 | 93' | 90' | 53' | 95' |
| Ls2 | 93' | 90' | 53' | 95' |
| V | 40MPH | 25MPH | 25MPH | 25MPH |

### TRACK 4 CURVE DATA

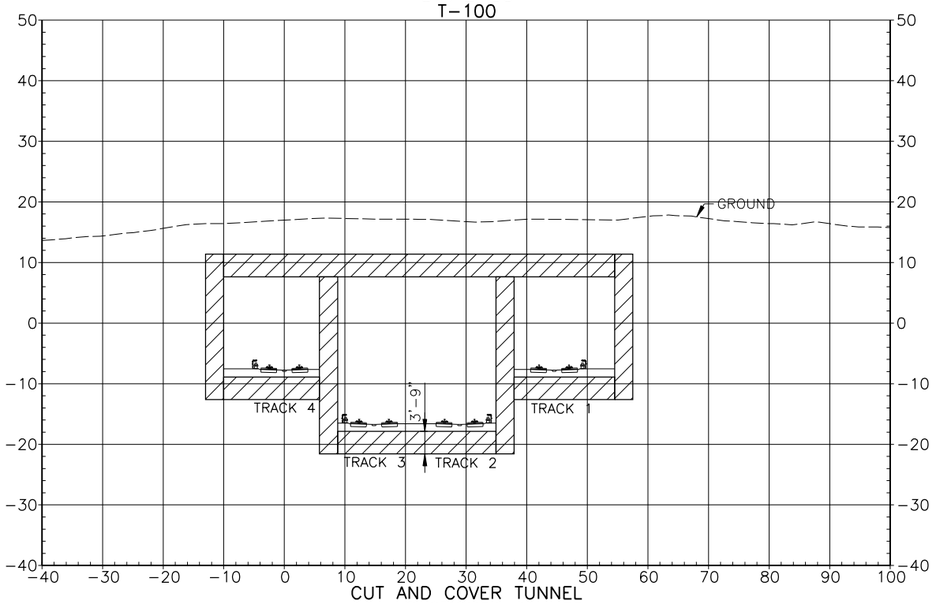
| CURVE | 4–3 | 4–4 | 4–5 | 4–6 |
|---|---|---|---|---|
| R | 1000' | 600' | 750' | 550' |
| Ls1 | 93' | 90' | 53' | 95' |
| Ls2 | 93' | 90' | 53' | 95' |
| V | 40MPH | 25MPH | 25MPH | 25MPH |



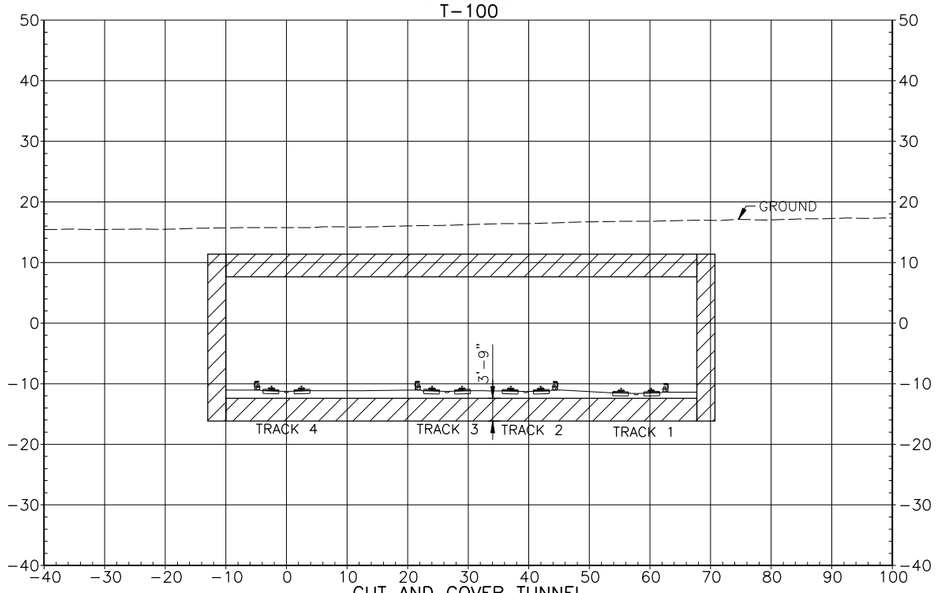

CUT AND COVER TUNNEL
SECTION B–B
STA 2+50
T–100




CUT AND COVER/BORED TUNNEL
SECTION D–D
STA 7+00
T–100



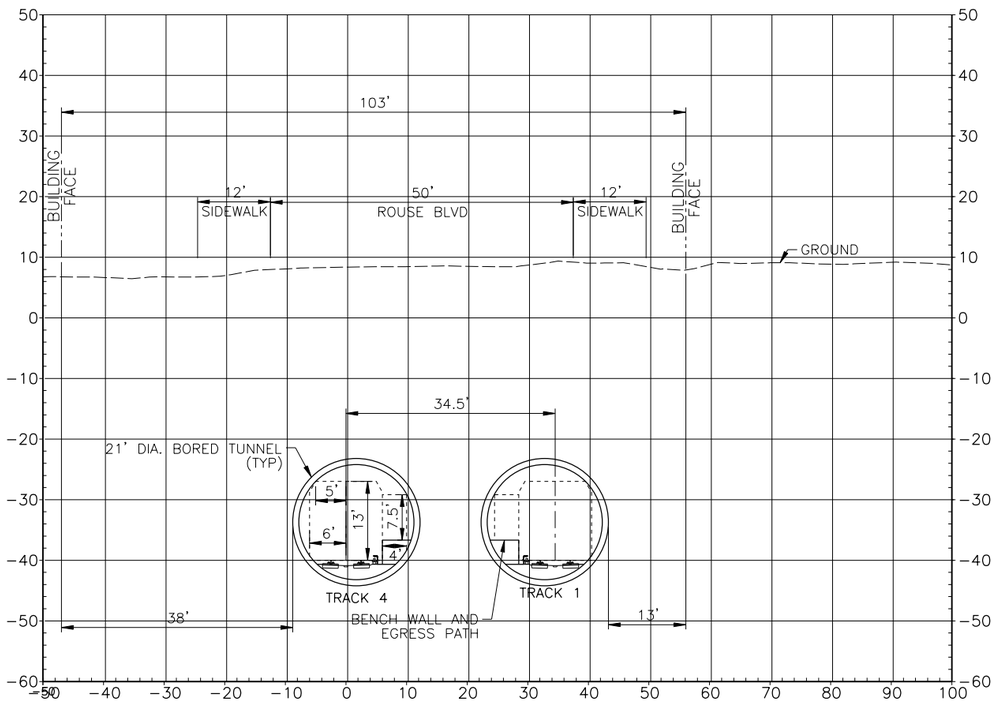

CUT AND COVER TUNNEL
SECTION A–A
STA 0+50
T–100



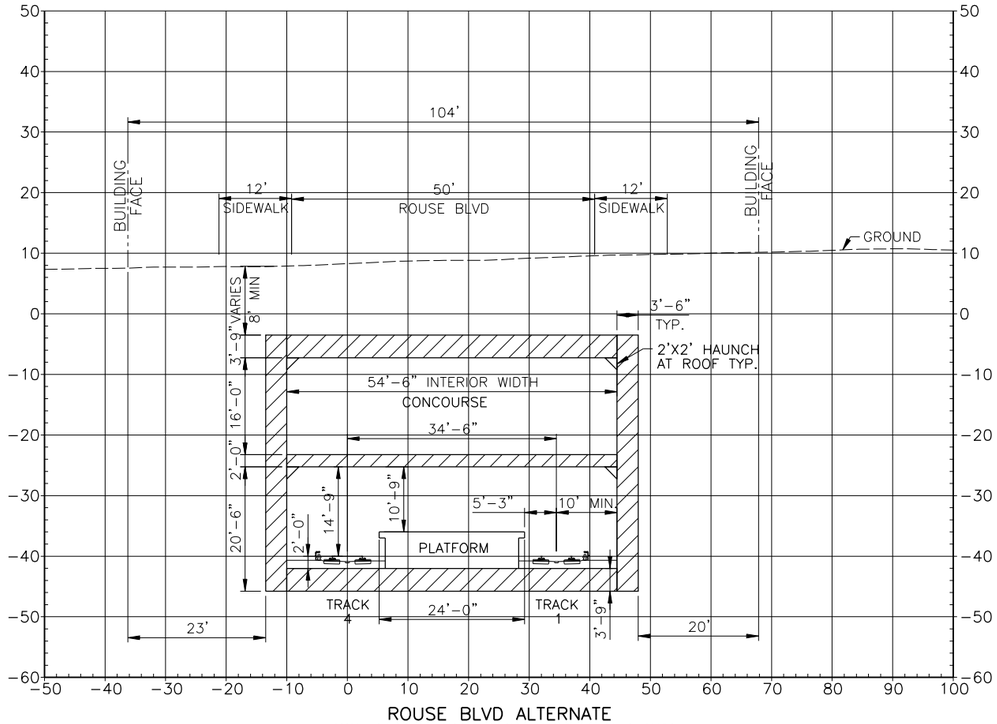

CUT AND COVER TUNNEL
SECTION C–C
STA 5+00
T–100

NOTES:
1. SUPPORT OF EXCAVATION AND GROUND IMPROVEMENT NOT SHOWN
2. UTILITIES NOT SHOWN IN SECTION VIEW FOR CLARITY

0 12.5 25
SCALE IN FEET




ROUSE BLVD ALTERNATE
BORED TUNNEL
SECTION A–A
STA 29+50
T–101




ROUSE BLVD ALTERNATE
TWO–LEVEL CUT AND COVER STATION
SECTION B–B
STA 44+00
T–101

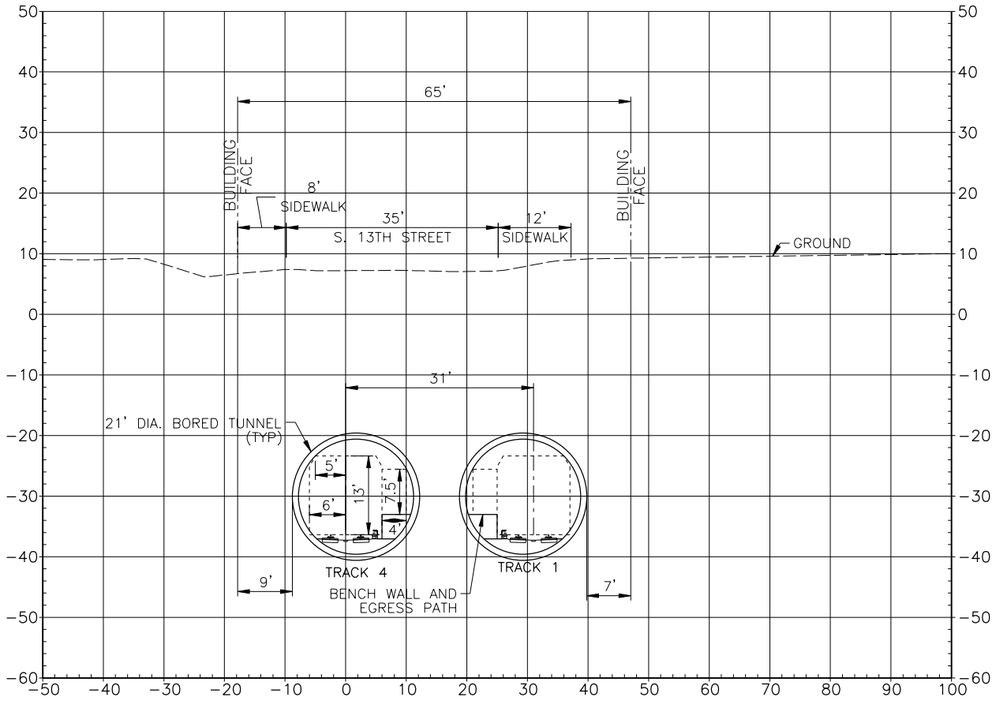
NOTES:
1. SUPPORT OF EXCAVATION AND GROUND IMPROVEMENT NOT SHOWN
2. UTILITIES NOT SHOWN IN SECTION VIEW FOR CLARITY

0 12.5 25
SCALE IN FEET

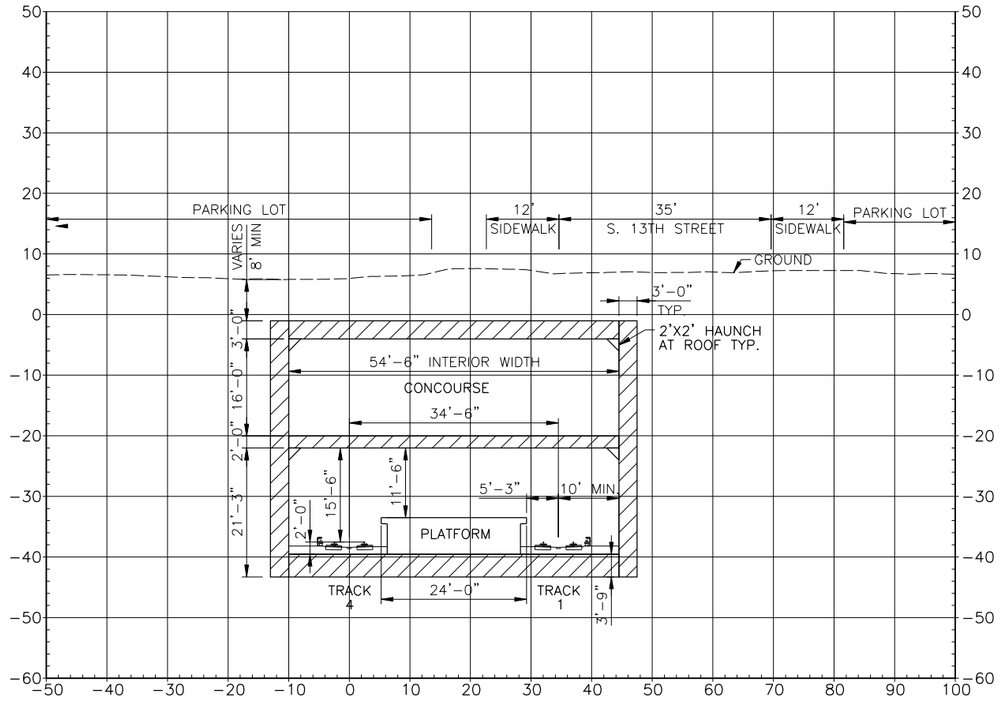
# SEPTA BROAD STREET LINE EXTENSION

## 13TH STREET ALTERNATE – CROSS SECTIONS






13TH STREET ALTERNATE
BORED TUNNEL UNDER 13TH STREET
SECTION A–A
STA 30+00
T–102

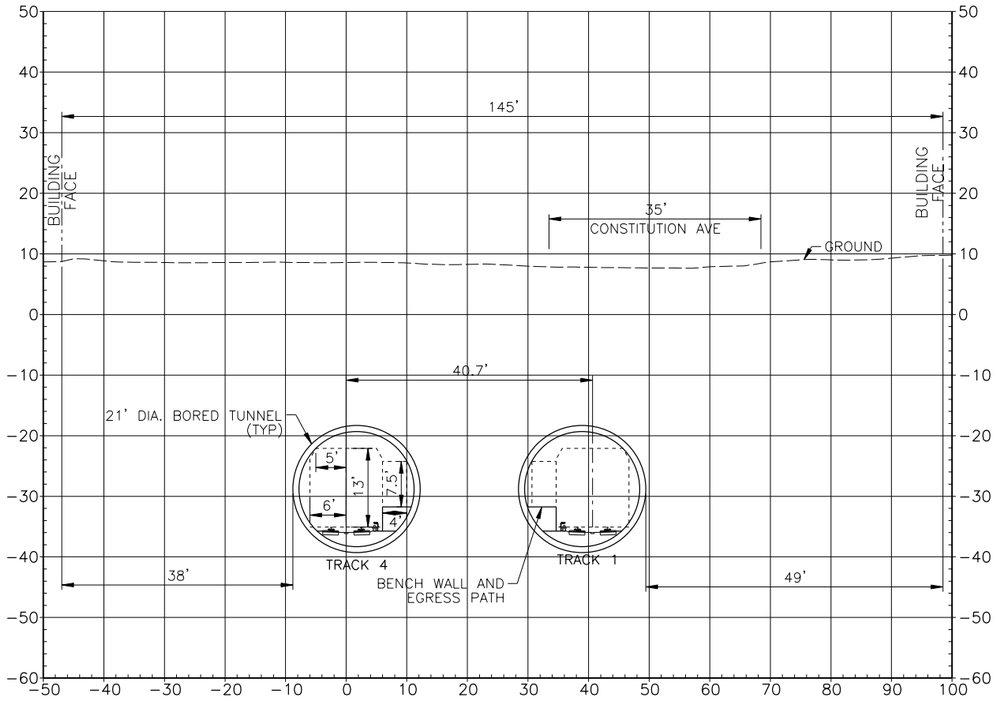



13TH STREET ALTERNATE
TWO–LEVEL CUT AND COVER STATION
SECTION B–B
STA 36+00
T–102

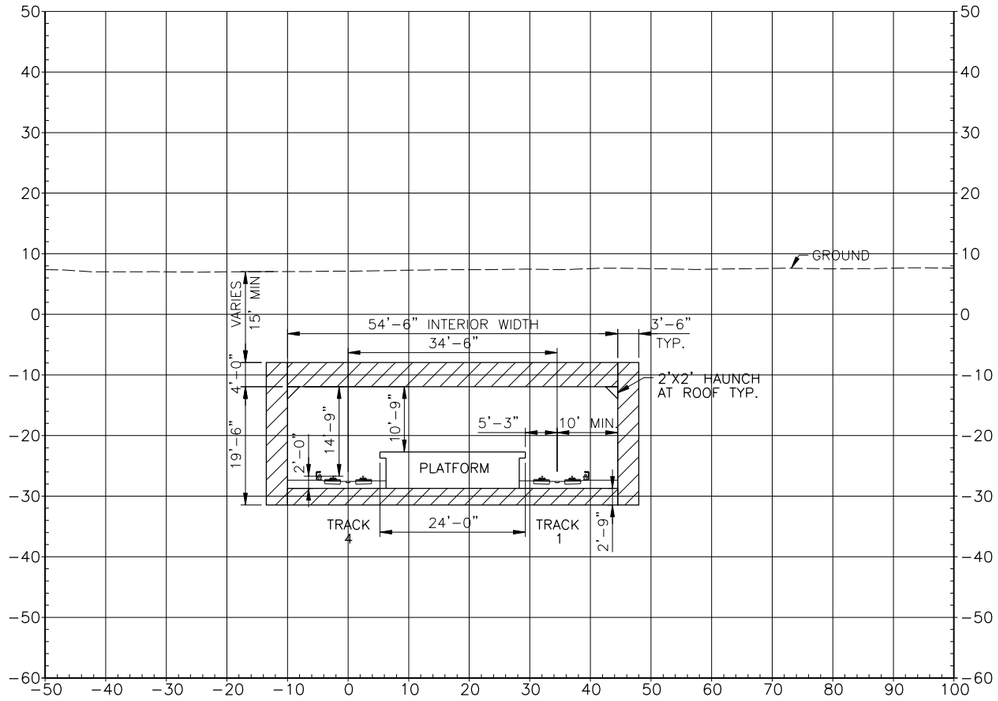
NOTES:

1. SUPPORT OF EXCAVATION AND GROUND IMPROVEMENT NOT SHOWN
2. UTILITIES NOT SHOWN IN SECTION VIEW FOR CLARITY

0 12.5 25
SCALE IN FEET




13TH STREET ALTERNATE
BORED TUNNEL UNDER CONSTITUTION AVE
SECTION C–C
STA 47+10
T–102

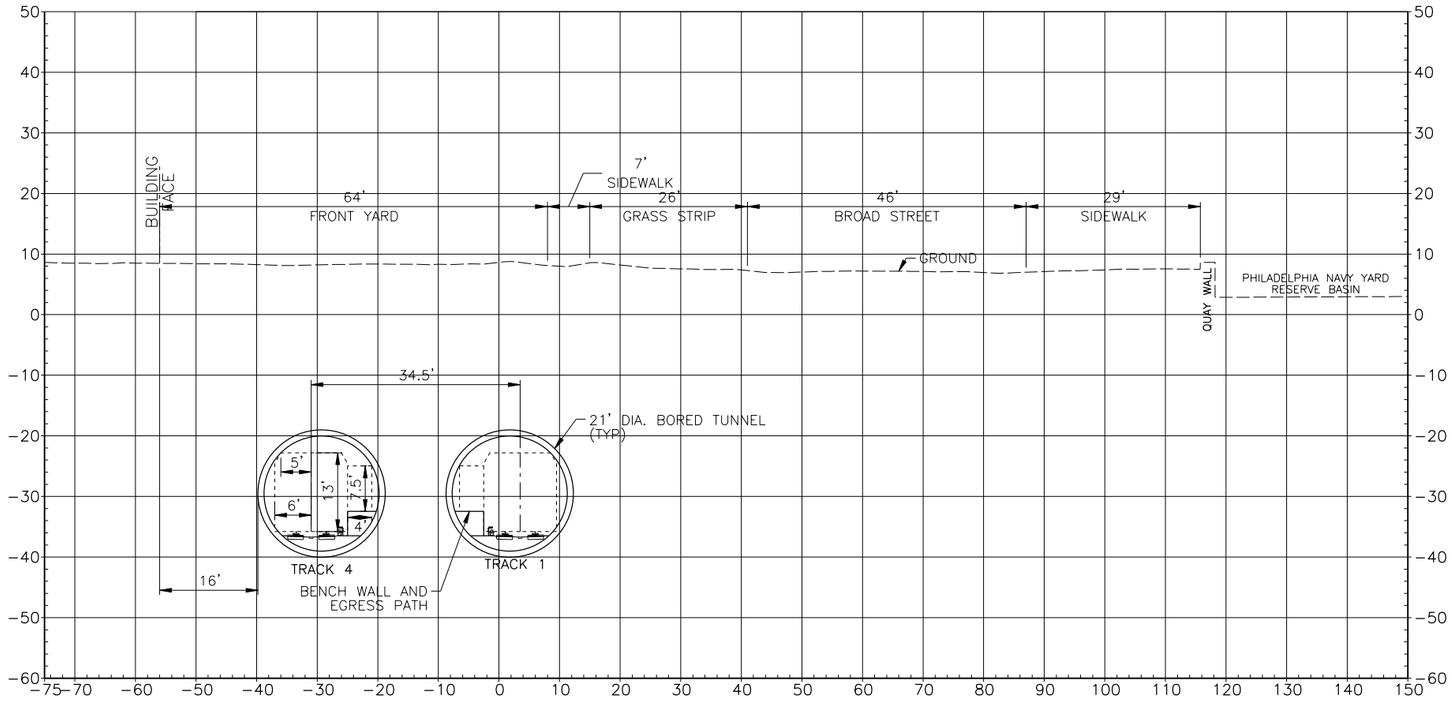



13TH STREET ALTERNATE
ONE–LEVEL CUT AND COVER STATION
SECTION D–D
STA 66+50
T–102

BROAD STREET ALTERNATE
ONE–LEVEL CUT AND COVER STATION
SECTION D–D
STA 81+25
T–103

NOTES:
1. SUPPORT OF EXCAVATION AND GROUND IMPROVEMENT NOT SHOWN
2. UTILITIES NOT SHOWN IN SECTION VIEW FOR CLARITY

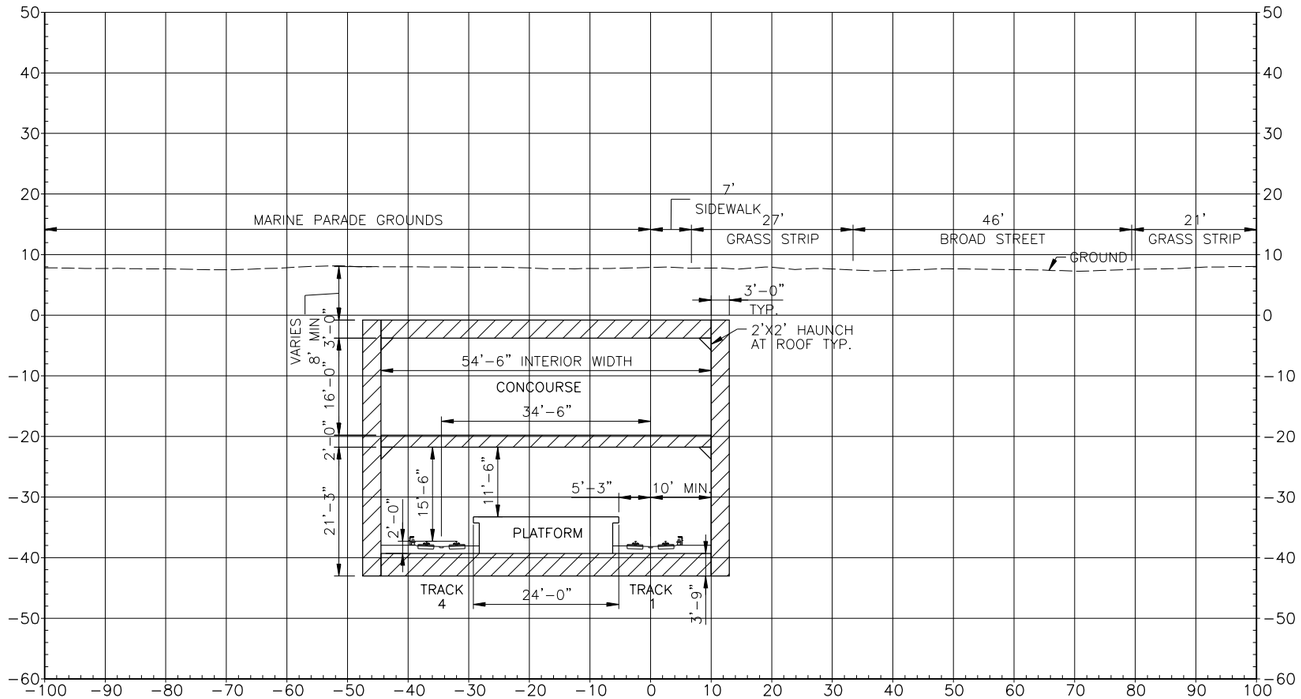
0 12.5 25
SCALE IN FEET



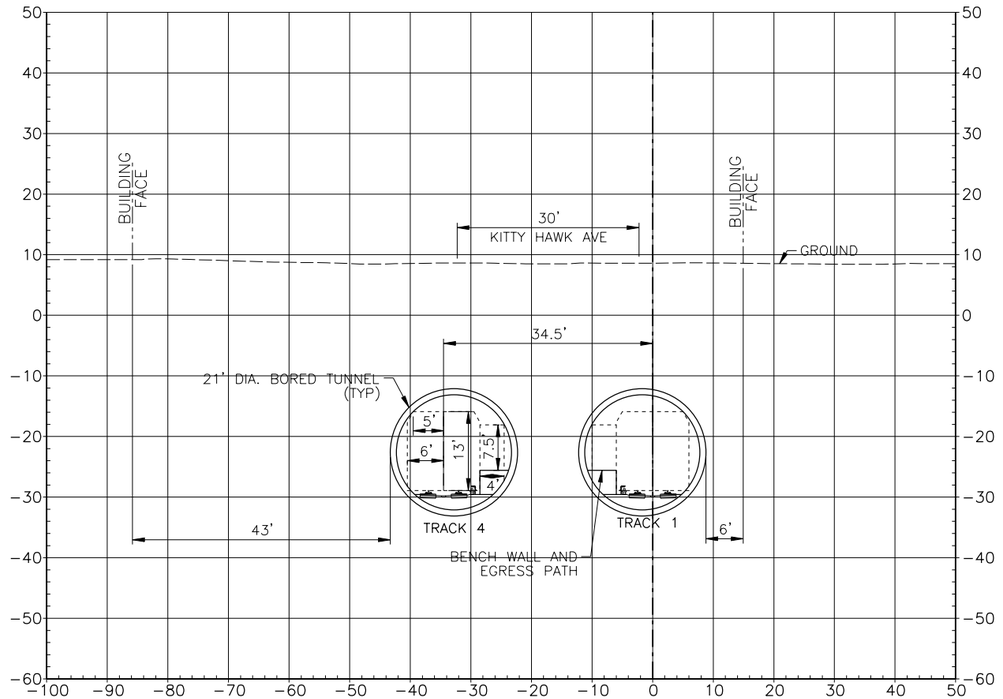

BROAD STREET ALTERNATE
BORED TUNNEL UNDER BROAD STREET
SECTION A–A
STA 33+50
T–103

NOTES:
1. SUPPORT OF EXCAVATION AND GROUND IMPROVEMENT NOT SHOWN
2. UTILITIES NOT SHOWN IN SECTION VIEW FOR CLARITY

0 12.5 25
SCALE IN FEET




BROAD STREET ALTERNATE
TWO-LEVEL CUT AND COVER STATION
SECTION B-B
STA 43+00
T-103




BROAD STREET ALTERNATE
BORED TUNNEL UNDER KITTY HAWK AVENUE
SECTION C-C
STA 59+00
T-103

NOTES:
1. SUPPORT OF EXCAVATION AND GROUND IMPROVEMENT NOT SHOWN
2. UTILITIES NOT SHOWN IN SECTION VIEW FOR CLARITY

0 12.5 25
SCALE IN FEET

# APPENDIX C

SUBWAY ALTERNATIVES 1 – 3 OPERATING PLAN TIMETABLES

The operating plan assumptions for the analyzed subway scenarios 1, 2, and 3 are summarized in Table E-1 below, followed by the operating plan schedules / timetables.

| Scenario | Rail | Bus | |
|---|---|---|---|
| | | Loop | Express |
| **2013 BASE: Existing transit system** | No change - BSL subway terminates at NRG Station | *Loop* and *Express* shuttles (PIDC-operated). 2013 schedules. | |
| | | • 38 daily runs<br>• operates 5:38AM-7:14PM<br>• 18 mins runtime<br>• 22 mins headways | • 36 daily runs<br>• operates 6:18AM-7:33PM, mid-day break<br>• 33 mins AM runtime, 43 mins PM<br>• headways: 5 to 35 mins |
| **2040 NO BUILD: Existing transit system w/ funded elements** | No changes to BSL route or schedule | *Loop* and *Express* shuttles (PIDC-operated). End of 2016 schedules, modified for 2040 traffic conditions. | |
| | | • 60 daily runs<br>• operates 5:38AM-7:14PM<br>• 22 mins runtime<br>• 13.5 mins headways<br>• clockwise & counterclockwise service | • 48 daily runs<br>• operates 6:18AM-7:30PM, mid-day break<br>• 42 mins runtime AM, 55 mins runtime PM<br>• headways: 7 to 35 mins |
| **ALT 1: RAIL Rouse / Central Green** | Extends BSL to Navy Yard;<br>1 new station on Rouse Blvd. | *Loop* and *Express* shuttles (operator TBD) | |
| | | *East Loop*<br>• 130 daily runs<br>• 10 min end-to-end runtime<br>• headways: 7 to 25 mins<br>• meets every inbound Rouse Blvd BSL train AM, runs counterclockwise; and, every outbound train PM, runs clockwise<br>*West Loop*<br>• 65 daily runs<br>• 13 min end-to-end runtime<br>• headways: 14 to 40 mins<br>• meets every other inbound Rouse Blvd BSL train in AM, runs clockwise; and, every other outbound train PM, runs counterclockwise | N/A (No Express) |

| Scenario | Rail | Bus | |
|---|---|---|---|
| | | Loop | Express |
| **ALT 2: RAIL 13th & Constitution** | Extends BSL to Navy Yard;<br>2 new stations: 13th St. & Kitty Hawk Ave. | Similar to Alt 1. Variations in operating plan due to trips originating/terminating at the new BSL 13th Street Station. | N/A (No Express) |
| **ALT 3: RAIL Broad & Kitty Hawk** | Extends BSL to Navy Yard;<br>2 new stations: Broad St. & Kitty Hawk Ave | Similar to Alt 1. Variations in operating plan due to trips originating/terminating at the new BSL Broad St. / Constitution Station. | N/A (No Express) |

**Table E-1 – Subway Scenarios Operating Plan Assumptions**

# 2040 NO BUILD SCENARIO

## NAVY YARD EXPRESS BUS

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| 10th & Market | | 0:00:00 |
| Market & 4th | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:29:30 | 0:31:30 |
| League Island & Kitty Hawk | 0:06:00 | 0:37:30 |
| Broad & Kitty Hawk | 0:02:00 | 0:39:30 |
| Broad & Intrepid | 0:02:00 | 0:41:30 |
| 10th & Market | 0:19:30 | 1:01:00 |

**Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| League Island & Crescent | | 0:00:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:02:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:04:00 |
| Broad & Intrepid | 0:02:00 | 0:06:00 |
| 10th & Market | 0:17:00 | 0:23:00 |
| Market & 4th | 0:04:00 | 0:27:00 |
| League Island & Crescent | 0:16:00 | 0:43:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| League Island & Crescent | | 0:00:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:02:00 |
| Broad & Kitty Hawk | 0:03:00 | 0:05:00 |
| Broad & Intrepid | 0:08:00 | 0:13:00 |
| 10th & Market | 0:27:30 | 0:40:30 |
| Market & 4th | 0:04:00 | 0:44:30 |
| League Island & Crescent | 0:14:30 | 0:59:00 |

## NAVY YARD LOOP

### CLOCKWISE

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:14:00 | 0:16:00 |
| League Island & Kitty Hawk | 0:07:00 | 0:23:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:25:00 |
| TastyKake | 0:04:00 | 0:29:00 |
| Langley & Broad | 0:04:00 | 0:33:00 |
| NRG | 0:02:00 | 0:35:00 |

**Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:05:00 | 0:07:00 |
| League Island & Kitty Hawk | 0:03:00 | 0:10:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:12:00 |
| TastyKake | 0:04:00 | 0:16:00 |
| Langley & Broad | 0:04:00 | 0:20:00 |
| NRG | 0:02:00 | 0:22:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:05:00 | 0:07:00 |
| League Island & Kitty Hawk | 0:03:00 | 0:10:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:12:00 |
| TastyKake | 0:04:00 | 0:16:00 |
| Langley & Broad | 0:05:00 | 0:21:00 |
| NRG | 0:10:00 | 0:31:00 |

## COUNTERCLOCKWISE

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Langley & Broad | 0:06:00 | 0:06:00 |
| TastyKake | 0:05:00 | 0:11:00 |
| Broad & Kitty Hawk | 0:10:00 | 0:21:00 |
| League Island & Kitty Hawk | 0:03:00 | 0:24:00 |
| League Island & Crescent | 0:03:00 | 0:27:00 |
| 11th & Stadium | 0:03:00 | 0:30:00 |
| NRG | 0:02:00 | 0:32:00 |

**Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Langley & Broad | 0:03:00 | 0:03:00 |
| TastyKake | 0:04:00 | 0:07:00 |
| Broad & Kitty Hawk | 0:05:00 | 0:12:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:14:00 |
| League Island & Crescent | 0:03:00 | 0:17:00 |
| 11th & Stadium | 0:03:00 | 0:20:00 |
| NRG | 0:02:00 | 0:22:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Langley & Broad | 0:03:00 | 0:03:00 |
| TastyKake | 0:04:00 | 0:07:00 |
| Broad & Kitty Hawk | 0:05:00 | 0:12:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:14:00 |
| League Island & Crescent | 0:06:00 | 0:20:00 |
| 11th & Stadium | 0:10:00 | 0:30:00 |
| NRG | 0:02:00 | 0:32:00 |

# 2040 BUILD SCENARIOS

## NAVY YARD LOOP BUS

### EAST

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| Kitty Hawk Station | | 0:00:00 |
| Central Green | 0:01:00 | 0:01:00 |
| League Island & Crescent | 0:01:00 | 0:02:00 |
| Broad & Intrepid | 0:14:00 | 0:16:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:18:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:20:00 |
| Mustin Park | 0:02:00 | 0:22:00 |
| Kitty Hawk Station | 0:01:00 | 0:23:00 |

**Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| Kitty Hawk Station | | 0:00:00 |
| Mustin Park | 0:01:30 | 0:01:30 |
| League Island & Kitty Hawk | 0:01:30 | 0:03:00 |
| Broad & Kitty Hawk | 0:01:30 | 0:04:30 |
| Broad & Intrepid | 0:01:00 | 0:05:30 |
| League Island & Crescent | 0:02:00 | 0:07:30 |
| Central Green | 0:01:00 | 0:08:30 |
| Kitty Hawk Station | 0:01:30 | 0:10:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| Kitty Hawk Station | | 0:00:00 |
| Mustin Park | 0:01:30 | 0:01:30 |
| League Island & Kitty Hawk | 0:01:30 | 0:03:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:05:00 |
| Broad & Intrepid | 0:06:00 | 0:11:00 |
| League Island & Crescent | 0:06:00 | 0:17:00 |
| Central Green | 0:01:00 | 0:18:00 |
| Kitty Hawk Station | 0:01:30 | 0:19:30 |

## NAVY YARD LOOP BUS

### WEST

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| 13th & Intrepid | | 0:00:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:02:00 |
| Kitty Hawk & 21st | 0:02:00 | 0:04:00 |
| TastyKake | 0:02:30 | 0:06:30 |
| League Island & Crescent | 0:13:00 | 0:19:30 |
| 13th & Intrepid | 0:04:30 | 0:24:00 |

**Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| 13th & Intrepid | | 0:00:00 |
| League Island & Crescent | 0:02:00 | 0:02:00 |
| TastyKake | 0:03:00 | 0:05:00 |
| Kitty Hawk & 21st | 0:03:00 | 0:08:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:10:00 |
| 13th & Intrepid | 0:03:00 | 0:13:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| 13th & Intrepid | | 0:00:00 |
| League Island & Crescent | 0:05:00 | 0:05:00 |
| TastyKake | 0:08:00 | 0:13:00 |
| Kitty Hawk & 21st | 0:03:00 | 0:16:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:18:00 |
| 13th & Intrepid | 0:03:00 | 0:21:00 |

Note:
The 2040 Build Alternative 2 operating plan is included to represent all recommended horizon year Loop East and West shuttles timetables. Only minor variations in service runs are expected for the 2040 Build scenarios 1 and 3 due to the shuttles serving the new proposed subway stations in slightly different locations.

# APPENDIX D

BUS ALTERNATIVES 4 – 6 OPERATING PLAN TIMETABLES

The operating plan assumptions for the analyzed bus scenarios 4, 5, and 6 are summarized in Table F-1 below, followed by the operating plan schedules / timetables.

| Scenario | Rail | Bus | |
|---|---|---|---|
| | | Loop | Express |
| **2013 BASE: Existing transit system** | No change - BSL subway terminates at NRG Station | *Loop* and *Express* shuttles (PIDC-operated). 2013 schedules. | |
| | | • 38 daily runs<br>• operates 5:38AM-7:14PM<br>• 18 mins runtime<br>• 22 mins headways | • 36 daily runs<br>• operates 6:18AM-7:33PM, mid-day break<br>• 33 mins AM runtime, 43 mins PM<br>• headways: 5 to 35 mins |
| **2040 NO BUILD: Existing transit system w/ funded elements** | No changes to BSL route or schedule | *Loop* and *Express* shuttles (PIDC-operated). End of 2016 schedules, modified for 2040 traffic conditions. | |
| | | • 60 daily runs<br>• operates 5:38AM-7:14PM<br>• 22 mins runtime<br>• 13.5 mins headways<br>• clockwise & counterclockwise service | • 48 daily runs<br>• operates 6:18AM-7:30PM, mid-day break<br>• 42 mins runtime AM, 55 mins runtime PM<br>• headways: 7 to 35 mins |
| **ALT 4: BUS Loop** | No change - BSL subway terminates at NRG Station | *East Loop*<br>• ~130 daily runs<br>• 18 mins runtime<br>• meets every inbound NRG train AM, runs counterclockwise; and, every outbound train PM, runs clockwise<br>*West Loop*<br>• ~65 daily runs<br>• 18 mins runtime<br>• meets every other inbound train in AM, runs clockwise; and, every other outbound departing train in PM, runs counterclockwise | N/A (No Express) |
| **ALT 5: BUS Express & Loop** | No change | Same as Alt 4 | • 92 daily runs<br>• operates 4:30AM-12:00AM<br>• headways:<br>  ○ 4:30AM - 6:00AM, 30 mins<br>  ○ 6:00AM - 7:30PM, 10 mins<br>  ○ ○ 7:30 PM to midnight, 30 mins |

| Scenario | Rail | Bus | |
|---|---|---|---|
| | | Loop | Express |
| **ALT 6: BUS Route 45 & Loop** | No change | West Loop from Alt 4 / No East Loop | N/A (No Express) |
| | | Includes modified ROUTE 45 (different from *Loop* or *Express*) | |
| | | *Route 45* extended to Navy Yard via NRG Station<br>• extends every existing Route 45 run<br>• operates 5:06AM-2:26AM<br>• routing around Navy Yard similar to existing *Route 17* weekend Navy Yard alignment | |

**Table F-1 – Bus Scenarios Operating Plan Assumptions**

# 2040 NO BUILD SCENARIO

## NAVY YARD EXPRESS BUS

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| 10th & Market | | 0:00:00 |
| Market & 4th | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:29:30 | 0:31:30 |
| League Island & Kitty Hawk | 0:06:00 | 0:37:30 |
| Broad & Kitty Hawk | 0:02:00 | 0:39:30 |
| Broad & Intrepid | 0:02:00 | 0:41:30 |
| 10th & Market | 0:19:30 | 1:01:00 |

**Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| League Island & Crescent | | 0:00:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:02:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:04:00 |
| Broad & Intrepid | 0:02:00 | 0:06:00 |
| 10th & Market | 0:17:00 | 0:23:00 |
| Market & 4th | 0:04:00 | 0:27:00 |
| League Island & Crescent | 0:16:00 | 0:43:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| League Island & Crescent | | 0:00:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:02:00 |
| Broad & Kitty Hawk | 0:03:00 | 0:05:00 |
| Broad & Intrepid | 0:08:00 | 0:13:00 |
| 10th & Market | 0:27:30 | 0:40:30 |
| Market & 4th | 0:04:00 | 0:44:30 |
| League Island & Crescent | 0:14:30 | 0:59:00 |

## NAVY YARD LOOP BUS

### CLOCKWISE

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:14:00 | 0:16:00 |
| League Island & Kitty Hawk | 0:07:00 | 0:23:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:25:00 |
| TastyKake | 0:04:00 | 0:29:00 |
| Langley & Broad | 0:04:00 | 0:33:00 |
| NRG | 0:02:00 | 0:35:00 |

**Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:05:00 | 0:07:00 |
| League Island & Kitty Hawk | 0:03:00 | 0:10:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:12:00 |
| TastyKake | 0:04:00 | 0:16:00 |
| Langley & Broad | 0:04:00 | 0:20:00 |
| NRG | 0:02:00 | 0:22:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:05:00 | 0:07:00 |
| League Island & Kitty Hawk | 0:03:00 | 0:10:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:12:00 |
| TastyKake | 0:04:00 | 0:16:00 |
| Langley & Broad | 0:05:00 | 0:21:00 |
| NRG | 0:10:00 | 0:31:00 |

## COUNTERCLOCKWISE

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Langley & Broad | 0:06:00 | 0:06:00 |
| TastyKake | 0:05:00 | 0:11:00 |
| Broad & Kitty Hawk | 0:10:00 | 0:21:00 |
| League Island & Kitty Hawk | 0:03:00 | 0:24:00 |
| League Island & Crescent | 0:03:00 | 0:27:00 |
| 11th & Stadium | 0:03:00 | 0:30:00 |
| NRG | 0:02:00 | 0:32:00 |

**Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Langley & Broad | 0:03:00 | 0:03:00 |
| TastyKake | 0:04:00 | 0:07:00 |
| Broad & Kitty Hawk | 0:05:00 | 0:12:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:14:00 |
| League Island & Crescent | 0:03:00 | 0:17:00 |
| 11th & Stadium | 0:03:00 | 0:20:00 |
| NRG | 0:02:00 | 0:22:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Langley & Broad | 0:03:00 | 0:03:00 |
| TastyKake | 0:04:00 | 0:07:00 |
| Broad & Kitty Hawk | 0:05:00 | 0:12:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:14:00 |
| League Island & Crescent | 0:06:00 | 0:20:00 |
| 11th & Stadium | 0:10:00 | 0:30:00 |
| NRG | 0:02:00 | 0:32:00 |

# 2040 BUILD ALTERNATIVES 4 AND 5

## NAVY YARD EXPRESS BUS

**AM Peak (6:00 AM to 10:00 AM)**

| Stop | stop to stop | cumulative |
|---|---|---|
| 10th & Market | | 0:00:00 |
| Market & 4th | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:29:30 | 0:31:30 |
| Central Green | 0:02:00 | 0:33:30 |
| Mustin Park | 0:02:00 | 0:35:30 |
| Kitty Hawk & League Island | 0:02:00 | 0:37:30 |
| Broad & Kitty Hawk | 0:02:00 | 0:39:30 |
| Broad & Intrepid | 0:02:00 | 0:41:30 |
| 10th & Market | 0:19:30 | 1:01:00 |

**AM Off - Peak (4:30 to 6:00 AM, 10:00 AM to Noon)**

| Stop | stop to stop | cumulative |
|---|---|---|
| 10th & Market | | 0:00:00 |
| Market & 4th | 0:02:00 | 0:02:00 |
| League Island & Crescent | 0:15:00 | 0:17:00 |
| Central Green | 0:02:00 | 0:19:00 |
| Mustin Park | 0:02:00 | 0:21:00 |
| Kitty Hawk & League Island | 0:02:00 | 0:23:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:25:00 |
| Broad & Intrepid | 0:02:00 | 0:27:00 |
| 10th & Market | 0:19:30 | 0:46:30 |

**PM Peak (3:00 PM to 7:00 PM)**

| Stop | stop to stop | cumulative |
|---|---|---|
| League Island & Crescent | | 0:00:00 |
| Central Green | 0:02:00 | 0:02:00 |
| Mustin Park | 0:02:00 | 0:04:00 |
| Kitty Hawk & League Island | 0:02:00 | 0:06:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:08:00 |
| Broad & Intrepid | 0:02:00 | 0:10:00 |
| 10th & Market | 0:31:00 | 0:41:00 |
| Market & 4th | 0:04:00 | 0:45:00 |
| League Island & Crescent | 0:14:30 | 0:59:30 |

**PM Off - Peak (Noon to 3:00 PM, 7:00 PM to midnight)**

| Stop | stop to stop | cumulative |
|---|---|---|
| League Island & Crescent | | 0:00:00 |
| Central Green | 0:02:00 | 0:02:00 |
| Mustin Park | 0:02:00 | 0:04:00 |
| Kitty Hawk & League Island | 0:02:00 | 0:06:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:08:00 |
| Broad & Intrepid | 0:02:00 | 0:10:00 |
| 10th & Market | 0:22:00 | 0:32:00 |
| Market & 4th | 0:04:00 | 0:36:00 |
| League Island & Crescent | 0:13:00 | 0:49:00 |

# NAVY YARD LOOP BUS

## EAST

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Broad & Langley | 0:09:00 | 0:09:00 |
| Broad & Intrepid | 0:07:00 | 0:16:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:18:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:20:00 |
| Mustin Park | 0:02:00 | 0:22:00 |
| Crescent & Rouse | 0:02:00 | 0:24:00 |
| NRG | 0:03:00 | 0:27:00 |

**AM Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Broad & Langley | 0:04:00 | 0:04:00 |
| Broad & Intrepid | 0:03:00 | 0:07:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:09:00 |
| League Island & Kitty Hawk | 0:02:00 | 0:11:00 |
| Mustin Park | 0:02:00 | 0:13:00 |
| Crescent & Rouse | 0:02:00 | 0:15:00 |
| NRG | 0:03:00 | 0:18:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:01:30 | 0:01:30 |
| Broad & Langley | 0:02:00 | 0:03:30 |
| Crescent & Rouse | 0:01:00 | 0:04:30 |
| Mustin Park | 0:02:30 | 0:07:00 |
| Broad & Kitty Hawk | 0:03:00 | 0:10:00 |
| Broad & Crescent | 0:06:00 | 0:16:00 |
| NRG | 0:09:00 | 0:25:00 |

**PM Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:01:30 | 0:01:30 |
| Broad & Langley | 0:02:00 | 0:03:30 |
| Crescent & Rouse | 0:01:00 | 0:04:30 |
| Mustin Park | 0:02:30 | 0:07:00 |
| Broad & Kitty Hawk | 0:03:00 | 0:10:00 |
| Broad & Crescent | 0:04:00 | 0:14:00 |
| NRG | 0:04:00 | 0:18:00 |

# NAVY YARD LOOP BUS

## WEST

**AM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Broad & Langley | 0:09:00 | 0:09:00 |
| Broad & Intrepid | 0:07:00 | 0:16:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:18:00 |
| TastyKake | 0:04:00 | 0:22:00 |
| Broad & Langley | 0:03:00 | 0:25:00 |
| NRG | 0:04:00 | 0:29:00 |

**AM Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| Broad & Langley | 0:04:00 | 0:04:00 |
| Broad & Intrepid | 0:03:00 | 0:07:00 |
| Broad & Kitty Hawk | 0:02:00 | 0:09:00 |
| TastyKake | 0:04:00 | 0:13:00 |
| Broad & Langley | 0:03:00 | 0:16:00 |
| NRG | 0:04:00 | 0:20:00 |

**PM Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:01:30 | 0:01:30 |
| Broad & Langley | 0:02:00 | 0:03:30 |
| TastyKake | 0:03:00 | 0:06:30 |
| Broad & Kitty Hawk | 0:03:30 | 0:10:00 |
| Broad & Crescent | 0:06:00 | 0:16:00 |
| NRG | 0:09:00 | 0:25:00 |

**PM Off - Peak**

| Stop | stop to stop | cumulative |
|---|---|---|
| NRG | | 0:00:00 |
| 11th & Stadium | 0:01:30 | 0:01:30 |
| Broad & Langley | 0:02:00 | 0:03:30 |
| TastyKake | 0:03:00 | 0:06:30 |
| Broad & Kitty Hawk | 0:03:30 | 0:10:00 |
| Broad & Crescent | 0:04:00 | 0:14:00 |
| NRG | 0:04:00 | 0:18:00 |

# 2040 BUILD SCENARIO 6

## ROUTE 45

**AM Peak Southbound**

| Stop | stop to stop | cumulative |
|---|---|---|
| 12th & Noble | | 0:00:00 |
| 12th & Market | 0:06:00 | 0:06:00 |
| 12th & Washington | 0:11:00 | 0:17:00 |
| Broad & Packer/Oregon | 0:21:00 | 0:38:00 |
| Navy Yard Broad / Parade Ground | 0:21:00 | 0:59:00 |

**Mid Day Southbound**

| Stop | stop to stop | cumulative |
|---|---|---|
| 12th & Noble | | 0:00:00 |
| 12th & Market | 0:06:00 | 0:06:00 |
| 12th & Washington | 0:11:00 | 0:17:00 |
| Broad & Packer/Oregon | 0:18:00 | 0:35:00 |
| Navy Yard Broad / Parade Ground | 0:11:00 | 0:46:00 |

**PM Peak Southbound**

| Stop | stop to stop | cumulative |
|---|---|---|
| 12th & Noble | | 0:00:00 |
| 12th & Market | 0:06:00 | 0:06:00 |
| 12th & Washington | 0:10:00 | 0:16:00 |
| Broad & Packer/Oregon | 0:19:00 | 0:35:00 |
| Navy Yard Broad / Parade Ground | 0:11:00 | 0:46:00 |

**Night Southbound**

| Stop | stop to stop | cumulative |
|---|---|---|
| 12th & Noble | | 0:00:00 |
| 12th & Market | 0:06:00 | 0:06:00 |
| 12th & Washington | 0:10:00 | 0:16:00 |
| Broad & Packer/Oregon | 0:15:00 | 0:31:00 |
| Navy Yard Broad / Parade Ground | 0:10:00 | 0:41:00 |

**AM Peak Northbound**

| Stop | stop to stop | cumulative |
|---|---|---|
| Navy Yard Broad / Parade Ground | | 0:00:00 |
| Broad & Oregon | 0:12:00 | 0:12:00 |
| 11th & Washington | 0:18:00 | 0:30:00 |
| 11th & Market | 0:10:00 | 0:40:00 |
| 11th & Noble | 0:06:00 | 0:46:00 |

**Mid Day Northbound**

| Stop | stop to stop | cumulative |
|---|---|---|
| Navy Yard Broad / Parade Ground | | 0:00:00 |
| Broad & Oregon | 0:12:00 | 0:12:00 |
| 11th & Washington | 0:18:00 | 0:30:00 |
| 11th & Market | 0:10:00 | 0:40:00 |
| 11th & Noble | 0:06:00 | 0:46:00 |

**PM Peak Northbound**

| Stop | stop to stop | cumulative |
|---|---|---|
| Navy Yard Broad / Parade Ground | | 0:00:00 |
| Broad & Oregon | 0:24:00 | 0:24:00 |
| 11th & Washington | 0:18:00 | 0:42:00 |
| 11th & Market | 0:10:00 | 0:52:00 |
| 11th & Noble | 0:07:00 | 0:59:00 |

**Night Northbound**

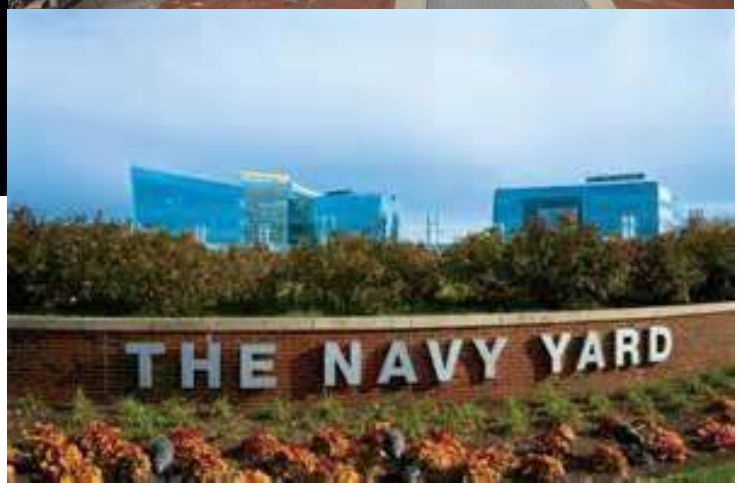
| Stop | stop to stop | cumulative |
|---|---|---|
| Navy Yard Broad / Parade Ground | | 0:00:00 |
| Broad & Oregon | 0:10:00 | 0:10:00 |
| 11th & Washington | 0:15:00 | 0:25:00 |
| 11th & Market | 0:10:00 | 0:35:00 |
| 11th & Noble | 0:06:00 | 0:41:00 |

# APPENDIX E

BROAD STREET LINE EXTENSION TO THE NAVY YARD - RIDERSHIP FORECAST PROCESS MEMORANDUM

# Broad Street Subway Line Extension to the Navy Yard Ridership Forecast

## Process Memorandum




DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION

| PROJECT COORDINATOR: | DELAWARE VALLEY REGIONAL PLANNING COMMISSION | PROJECT DATE: |
|---|---|---|
| **BRAD S. LANE, AICP** | | **November 2017** |
| | **PROCESS MEMORANDUM** | **DVRPC PUBLICATION # PM15062** |
| SUBJECT: **BROAD STREET SUBWAY LINE EXTENSION TO THE NAVY YARD RIDERSHIP FORECAST** | | |
| LOCATION: **SOUTH PHILADELPHIA** | | |

# Introduction

This memorandum summarizes the development of ridership forecasts for the proposed extension of the Broad Street Subway Line from its current southern terminus at AT&T Station (Pattison Avenue) to the Navy Yard.

The memo presents the assumptions and data that were used in the analysis, and explains how the DVRPC travel demand forecasting model was used to forecast future year ridership. Specific items discussed include the scenarios that were analyzed, the development and validation of the Base year model, and the development of the future year scenarios.

The memo then presents the future year ridership forecasts. This includes the number of passengers boarding and alighting at each station, by time period, and by mode of access (whether passengers walked, drove, or took a bus to the station). Finally, the memo discusses several sources of uncertainty in the ridership forecasts.

# Scenarios Analyzed

DVRPC analyzed the following scenarios for this project:

- 2013 Base
  Assumes current / existing (2013) land use, roadway, and transit networks.

- 2040 No Build
  Assumes future (2040) land use, roadway, and transit networks. Includes all of the projects in DVRPC's 2040 Long Range Plan.

Six 2040 Build alternatives were analyzed. All of the Build alternatives include the 2040 assumptions mentioned above for the 2040 No Build, as well as a version of the proposed project. Alternatives 1 through 3 extend the existing rail line south to the Navy Yard. Alternatives 4 through 6 provide a higher level of bus service to the Navy Yard. All six alternatives assume no parking fee in the Navy Yard, and that all shuttle and express bus service is free to passengers.

- 2040 Build Alternative 1 Rail –
  Includes proposed BSL subway extension with 1 station at Rouse Boulevard / Central Green

- 2040 Build Alternative 2 Rail –
  Includes proposed BSL subway extension with 2 stations at 13$^{th}$ Street and Kitty Hawk

- 2040 Build Alternative 3 Rail –
  Includes proposed BSL subway extension with 2 stations at Broad Street / Parade Ground and Kitty Hawk

- 2040 Build Alternative 4 Bus –
  Includes service expansion of existing Loop shuttle bus service between the Navy Yard and AT&T station

- 2040 Build Alternative 5 Bus –
  Includes expanded Loop shuttle bus service between the Navy Yard and AT&T station, and expanded Express bus service between the Navy Yard and central city Philadelphia

- 2040 Build Alternative 6 Bus –
  Includes expanded Loop shuttle bus service and extension of SEPTA Route 45 to the Navy Yard

## 2013 Base Scenario

DVRPC's current Travel Improvement Model version 2.2 (TIM 2.2) was used to analyze this project. TIM 2.2 is a best-in-class traditional 4-step (Trip Generation, Trip Distribution, Mode Choice, and Assignment) trip based model, built on the PTV Visum software platform. The model includes approximately 3,400 internal zones, 90,000 nodes, and 260,000 links, and has the following features:

- Total trip generation with motorized / non-motorized mode split based on trip-ends
- Trip distribution using a gravity model
- LOGIT mode choice model with true sub-nests for transit by access mode (walk, or drive)
- Multi-path transit assignment with transit sub-mode choice
- Quick precision LUCE origin based highway assignment algorithm
- High quality highway, transit, bicycle, and pedestrian networks derived from open source data

The model area includes DVRPC's nine member counties plus an extended outer ring of sixteen counties. The nine member counties are: Bucks, Chester, Delaware, Montgomery, and Philadelphia counties in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. The extended area includes Berks, Lancaster, Lehigh, and Northampton counties in Pennsylvania; Atlantic, Cape May, Cumberland, Hunterdon, Middlesex, Monmouth, Ocean, Salem, Somerset, and Warren counties in New Jersey; New Castle County in Delaware; and Cecil County in Maryland.

**Figure 1** shows the project study area. It roughly includes the area bordered by the Schuylkill River on the west, the Delaware River on the east and south, and I-76 (Schuylkill Expressway) on the north. In addition to I-76, this area is also traversed by I-95, and includes the stadium complex (Lincoln Financial Field, Citizens Bank Park, and the Wells Fargo Center), FDR Park, and the rail yard. The Navy Yard is located approximately 4 miles south of Center City and 1 mile south of AT&T station, the current terminus of the Broad Street Subway line.

For the purposes of this analysis, the model represents transportation on an average weekday. The day is divided into the following four time periods: AM Peak from 6:00 AM to 10:00 AM, Midday from 10:00 AM to 3:00 PM, PM Peak from 3:00 PM to 7:00 PM, and Evening from 7:00 PM to 6:00 AM.

In terms of land use, year 2013 land use was estimated by interpolating between 2010 and 2015. The 2010 data are from U.S. Census and National Establishment Time-Series (NETS) employment data[1], and the 2015 forecasts are based on Census and NETS. **Figure 2** shows the 22 Traffic Analysis Zones (TAZs) that comprise the City of Philadelphia's Lower South District. The Navy Yard is part of the Lower South District. **Figure 3** shows the seven TAZs (1801 – 1807) in the Navy Yard.

**Table** 1 shows the 2013 socio – economic data for the greater study area, encompassing the Lower South District. In most cases, these people and jobs would be within walking distance of the proposed rail extension. Transit dependent households are defined as those with an annual income of $35,000 or less.

[1] Delaware Valley Regional Planning Commission. *Analytical Data Report 19: Regional, County, and Municipal Employment Forecasts, 2010-2040*. January 2013.

In terms of the roadway network, there are two roads that provide direct access to the Navy Yard. Broad Street (PA 611) is a major north-south arterial running through the City of Philadelphia, that is three lanes in each direction at the main entrance to the Navy Yard. South 26th Street is a minor arterial that is one lane in each direction as it enters the Navy Yard. Any major roadway improvements that were constructed prior to, or during 2013 are included in the model. **Figure 4** shows the existing roadway network, color coded by the number of lanes in each direction.

There are currently 8,399 surface lot parking spaces (shown in **Figure 5**), and 1,068 on-street parking spaces (**Figure 6**), for a total of 9,467 spaces in the Navy Yard. There is almost one space for every employee. All parking in the Navy Yard is free. AT&T Station has a park-and-ride lot accessible by the sports stadium entrances (**Figure 7**) for people commuting to Center City. The cost to park there is $1 per day.

The transit network reflects the routes, schedules and fares that were in effect in 2013. SEPTA does not currently provide direct service to the Navy Yard, but it does have several routes that can get a passenger close. The Broad Street Subway Line (shown in **Figure 8**) stops approximately 1 mile north of the Navy Yard at AT&T station at the intersection of Broad Street and Pattison Avenue. Passengers can then transfer to the PIDC Loop shuttle (**Figure 9**) that links AT&T station with the Navy Yard. The subway operates continuously from 5 AM until midnight. Headways vary throughout the day, from 7 minutes during the morning and afternoon peaks, to 16 minutes in the off-peak. The Loop shuttle operates continuously from 5:30 AM to 7:30 PM. It does 38 complete trips, from AT&T station, a clockwise loop through the Navy Yard, and then back to AT&T each day. The headway is 22 minutes throughout the day. The travel time from AT&T to the first stop in the Navy Yard is 5 minutes. The total travel time for the entire route is 18 minutes.

The other main transit option to the Navy Yard is the PIDC Express Shuttle (**Figure 10**). The Express provides direct service between Center City Philadelphia and the Navy Yard via I-95 every weekday. It operates between 6 AM and 8 PM, with a mid-day break. Average headway during the AM peak is 14 minutes, and 16 minutes during the PM peak. It makes 36 trips each day, from the intersection of 10th and Market Streets in downtown, to the Navy Yard, makes 5 stops in the Navy Yard, and then returns to 10th and Market. Travel time from downtown to the first stop in the Navy Yard is 13 minutes during the morning peak. End to end travel time varies from 33 to 43 minutes, depending on time of day.

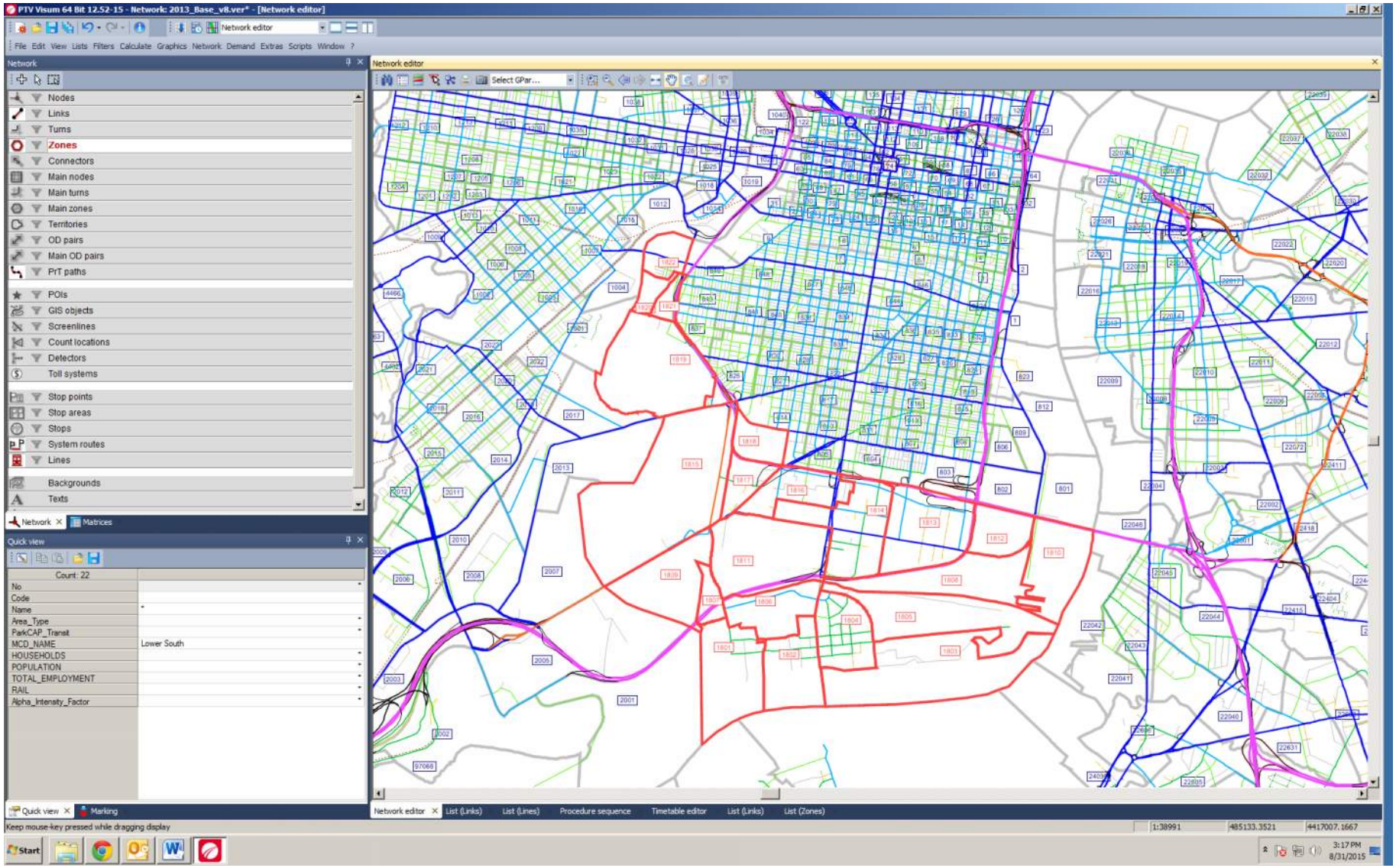
SEPTA also has several bus routes that provide limited service to the Navy Yard. These include the Route 68 bus which provides three late night runs for 3rd shift employees working at the TastyKake bakery on Basin Bridge Road. Both the Route 4 and 45 buses also connect AT&T station with Center City.

Passengers pay the base transit fare to ride the Broad Street Subway and bus Routes 4, 45, and 68. The PIDC Loop and Express shuttle buses are free of charge.

**Figure 1: Project Study Area**

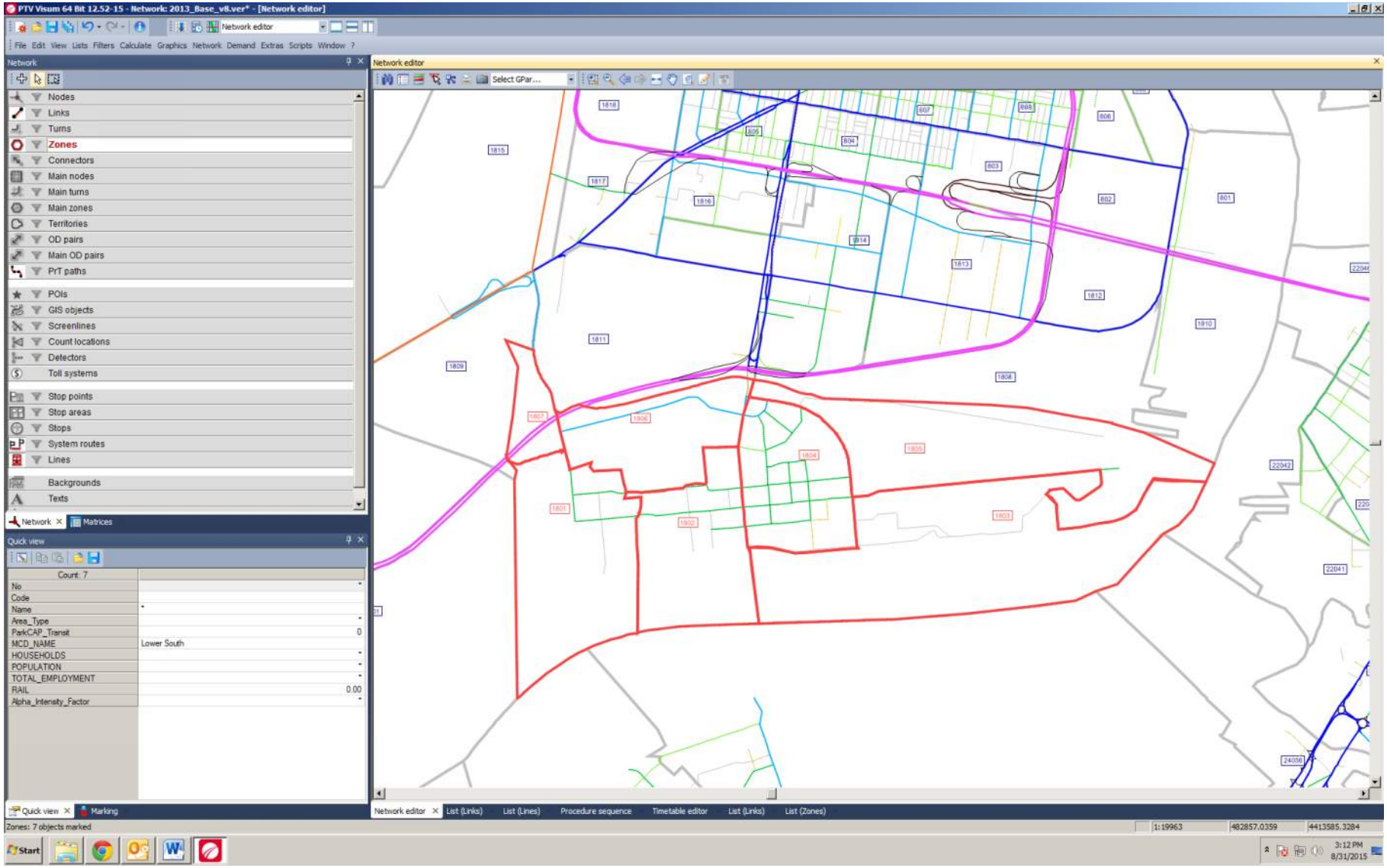

Source: PIDC, 2016

**Figure 2: Lower South District TAZs** (shown in red)




Source: Delaware Valley Regional Planning Commission, 2016

**Figure 3: The Seven Navy Yard TAZs**



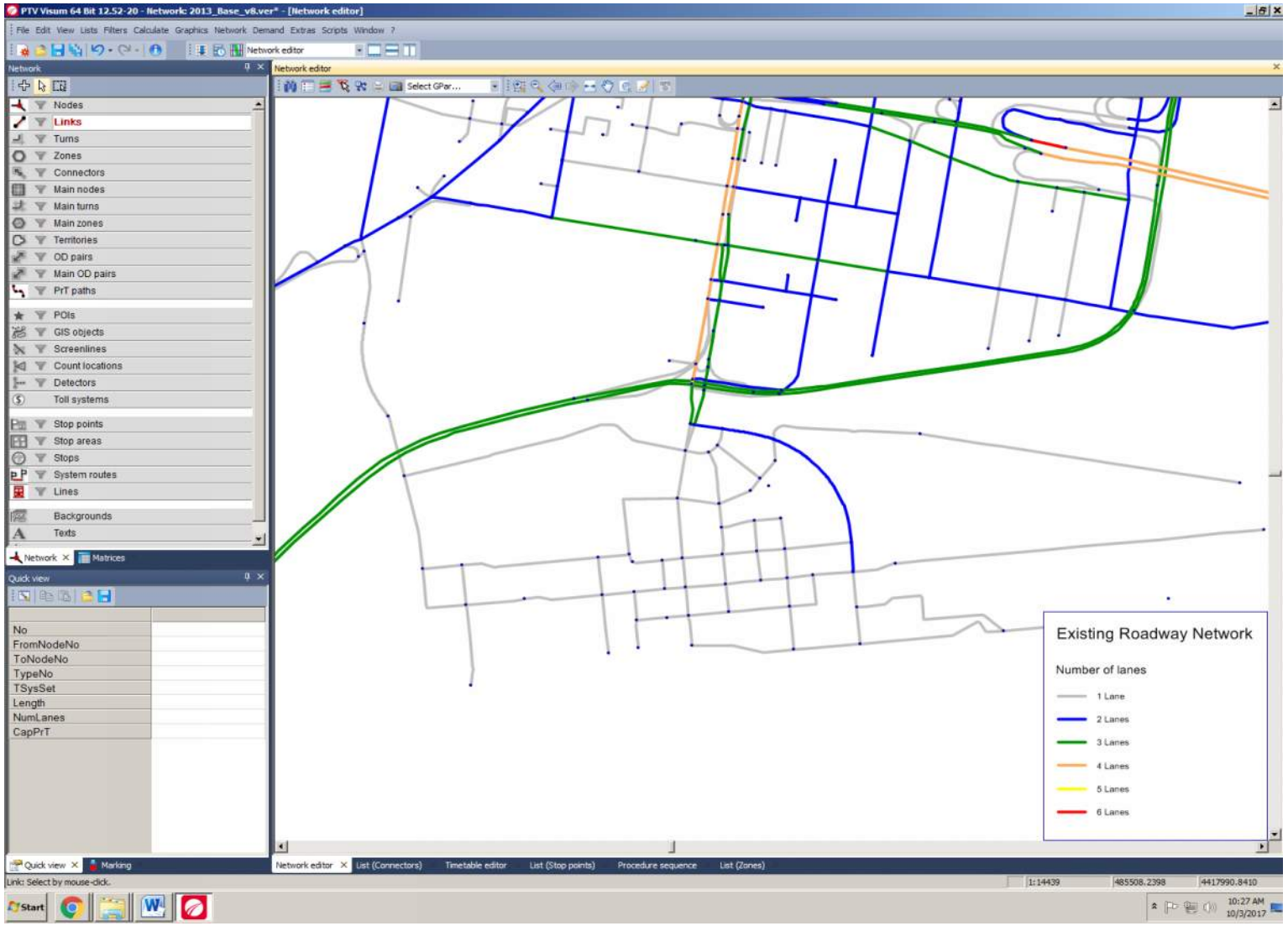

Source: Delaware Valley Regional Planning Commission, 2016

**Table 1: 2013 Land Use for the Navy Yard, and Lower South District**

| TAZ | Location | | Population | Households | | Employment |
|---|---|---|---|---|---|---|
| | | | | <= $35,000 | >$35,000 | |
| 1801 | Navy Yard | | 0 | 0 | 0 | 1,102 |
| 1802 | Navy Yard | | 0 | 0 | 0 | 2,500 |
| 1803 | Navy Yard | | 0 | 0 | 0 | 10 |
| 1804 | Navy Yard | | 0 | 0 | 0 | 3,910 |
| 1805 | Navy Yard | | 0 | 0 | 0 | 344 |
| 1806 | Navy Yard | | 0 | 0 | 0 | 1,265 |
| 1807 | Navy Yard | | 0 | 0 | 0 | 769 |
| | | Sub-Total | 0 | 0 | 0 | 9,900 |
| | | | | | | |
| 1808 | CSX Intermodal | | 4 | 0 | 0 | 150 |
| 1809 | | | 0 | 0 | 0 | 30 |
| 1810 | Packer Ave Marine Terminal | | 0 | 0 | 0 | 451 |
| 1811 | FDR Park | | 1,125 | 396 | 283 | 50 |
| 1812 | Whiskey Yard | | 0 | 0 | 0 | 200 |
| 1813 | Food Distribution | | 0 | 0 | 0 | 2,699 |
| 1814 | Stadiums | | 0 | 0 | 0 | 2,100 |
| 1815 | | | 0 | 0 | 0 | 200 |
| 1816 | Packer Park | | 4,036 | 637 | 1,083 | 420 |
| 1817 | | | 32 | 10 | 2 | 360 |
| 1818 | | | 0 | 0 | 0 | 775 |
| 1819 | Sunoco | | 2 | 2 | 0 | 30 |
| 1820 | CSX Transflo | | 0 | 0 | 0 | 50 |
| 1821 | | | 7 | 3 | 0 | 175 |
| 1822 | | | 330 | 129 | 38 | 710 |
| | | Sub-Total | 5,536 | 1,177 | 1,406 | 8,400 |
| | | | | | | |
| | | **Lower South Total** | **5,536** | **2,583** | | **18,300** |

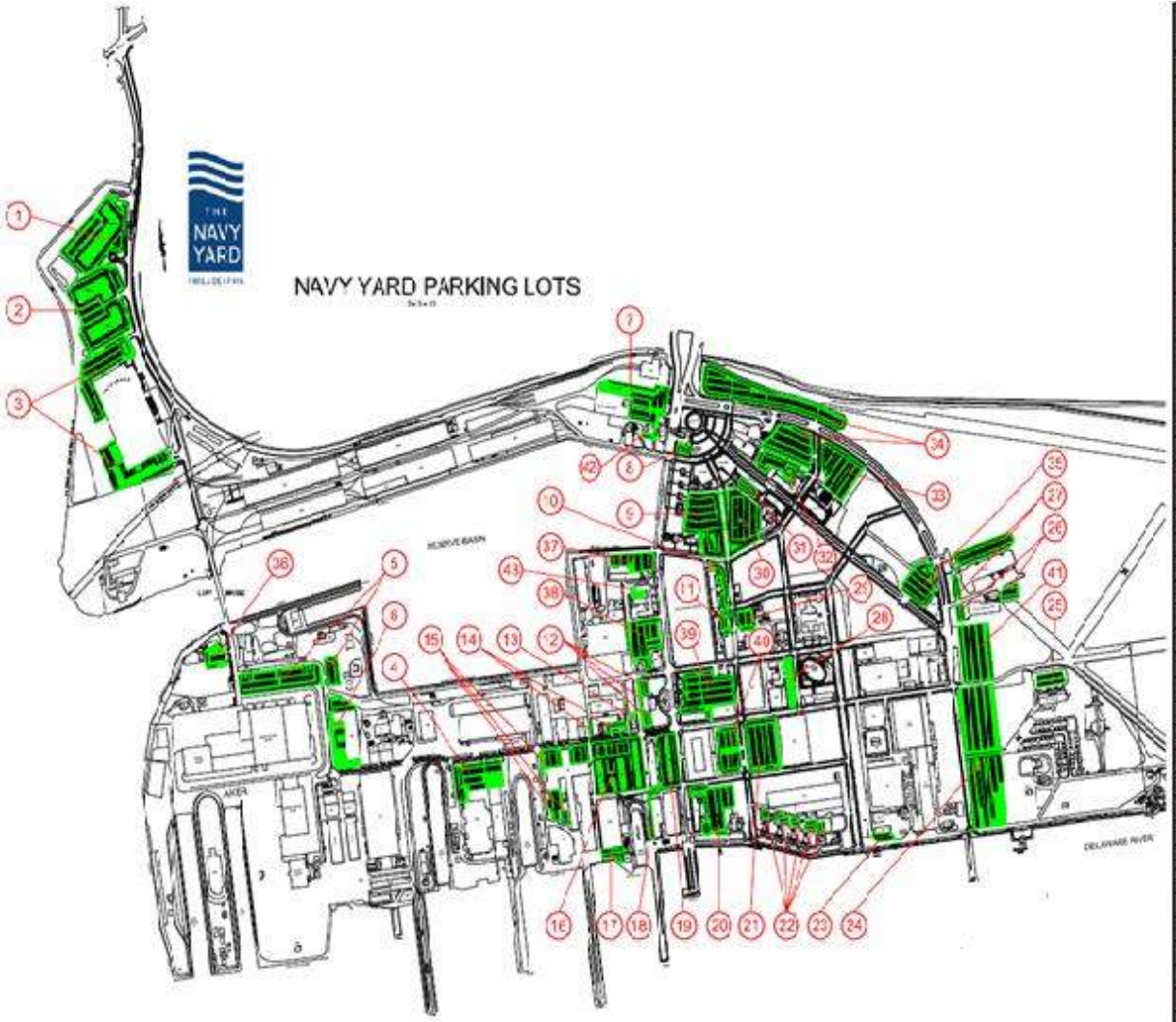
Source: Delaware Valley Regional Planning Commission, 2016

**Figure 4: Existing (2013) Roadway Network**




Source: Delaware Valley Regional Planning Commission, 2017

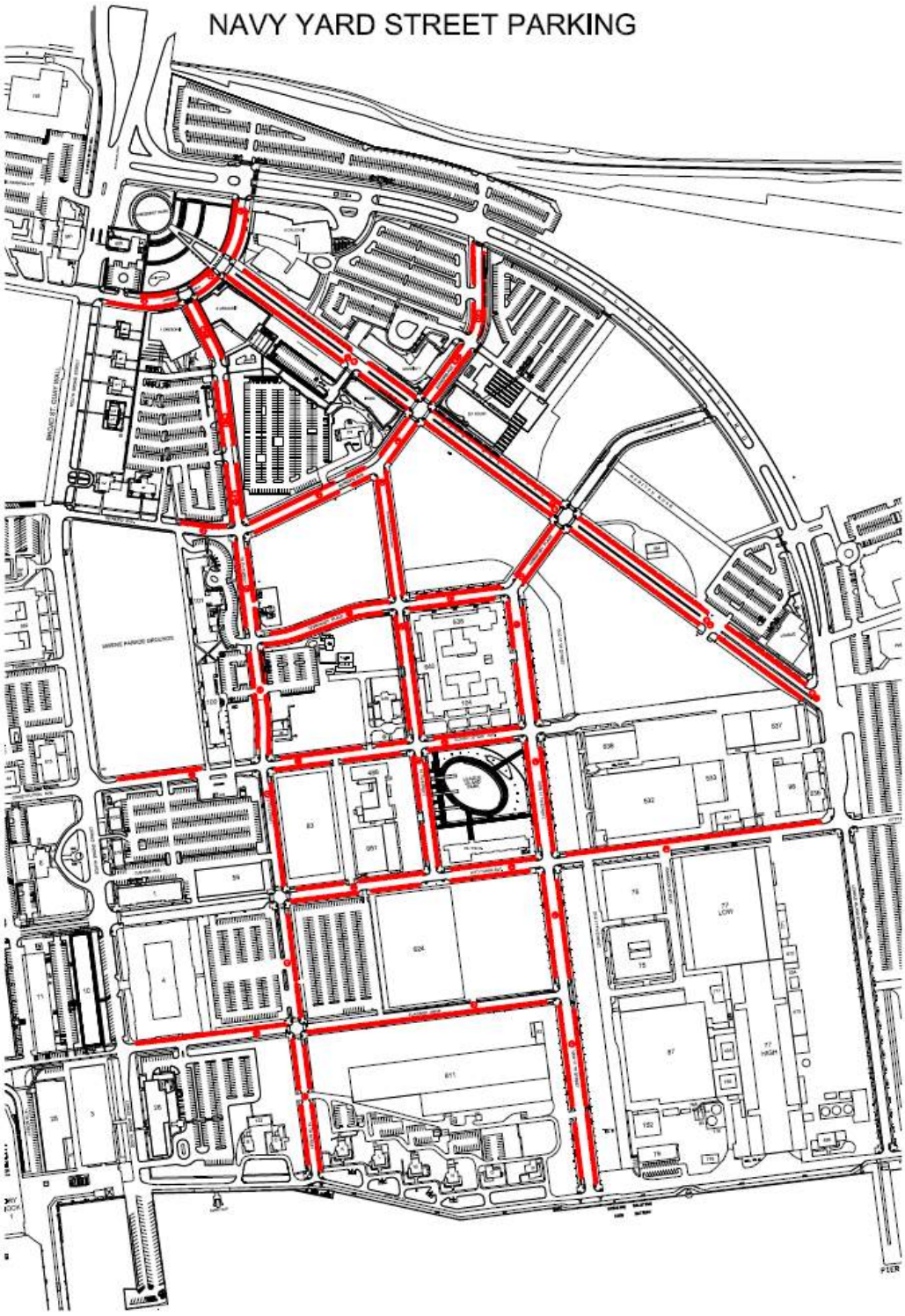
**Figure 5: Existing (2013) Parking Lots in Navy Yard**




| Lot Number & Description | # Of Spaces | % Of Use |
|---|---|---|
| 1 - Commerce 3 | 325 | 90% |
| 2 - Commerce 1 & 2 | 417 | 90% |
| 3 - TastyKake | 504 | 60% |
| 4 - U. S. Navy Building 1000 Complex | | 75% |
| 5 - Aker East & West | 389 | 65% |
| 6 - Building 990 Lots | | 60% |
| 7 - Police & West Lots | 243 | 70% |
| 8 - Crescent Park Lot | 22 | 90% |
| 9 - Crescent 1 & M-7 Lots | 330 | 100% |
| 10 - Building 101 Lot | 62 | 75% |
| 11 - Building 100 Lot | 42 | 80% |
| 12 - Building 6 Lots | 70 | 70% |
| 13 - Building 623 Lot | | 60% |
| 14 - Building 14 Lots | 48 | 70% |
| 15 - Building 18 Lots | 197 | 80% |
| 16 - Buildings 7, 12, and 15 | 216 | 90% |
| 17 - Building 543 | 46 | 90% |
| 18 - Building 25 Lot | 38 | 85% |
| 19 - Buildings 10 & 11 Lots | 115 | 90% |
| 20 - Building 26 Lot | 216 | 80% |
| 21 - Lot West of Building 624 | 306 | 10% |
| 22 - Qtrs K-L-M-N-O Lots | 81 | 60% |
| 23 - Building 79 Lot | 29 | 65% |
| 24 - S Lot South | 880 | 60% |
| 25 - Navy Lodge Lot | 78 | 90% |
| 26 - PTP Lots | 81 | 40% |
| 27 - Agptec Lots | 192 | 70% |
| 28 - Buildings 489 & 661 Lots | | 80% |
| 29 - 13th & Normandy Lot | 64 | 20% |
| 30 - Crescent 3 Lot | 328 | 100% |
| 31 - Irdko Lot | 40 | 100% |
| 32 - Marriott Lot | 111 | 70% |
| 33 - 201 Rouse Lot | 320 | 60% |
| 34 - Crescent 5 Lots | 900 | 70% |
| 35 - Unique Lot | 195 | 90% |
| 36 - Buildings 738 & 739 | 54 | 100% |
| 37 - U.S. Navy Building 29 | 104 | 100% |
| 38 - U.S. Navy Building 633 Complex | 236 | 100% |
| 39 - U.S. Navy Building 1 Complex | 409 | 100% |
| 40 - U.S. Navy Building 4 | 295 | 100% |
| 41 - U.S. Navy S Lot North | 400 | 20% |
| 42 - Building 501 & Qtrs A Lots | 16 | 70% |
| 43 - USN (Building 662) | 38 | 100% |

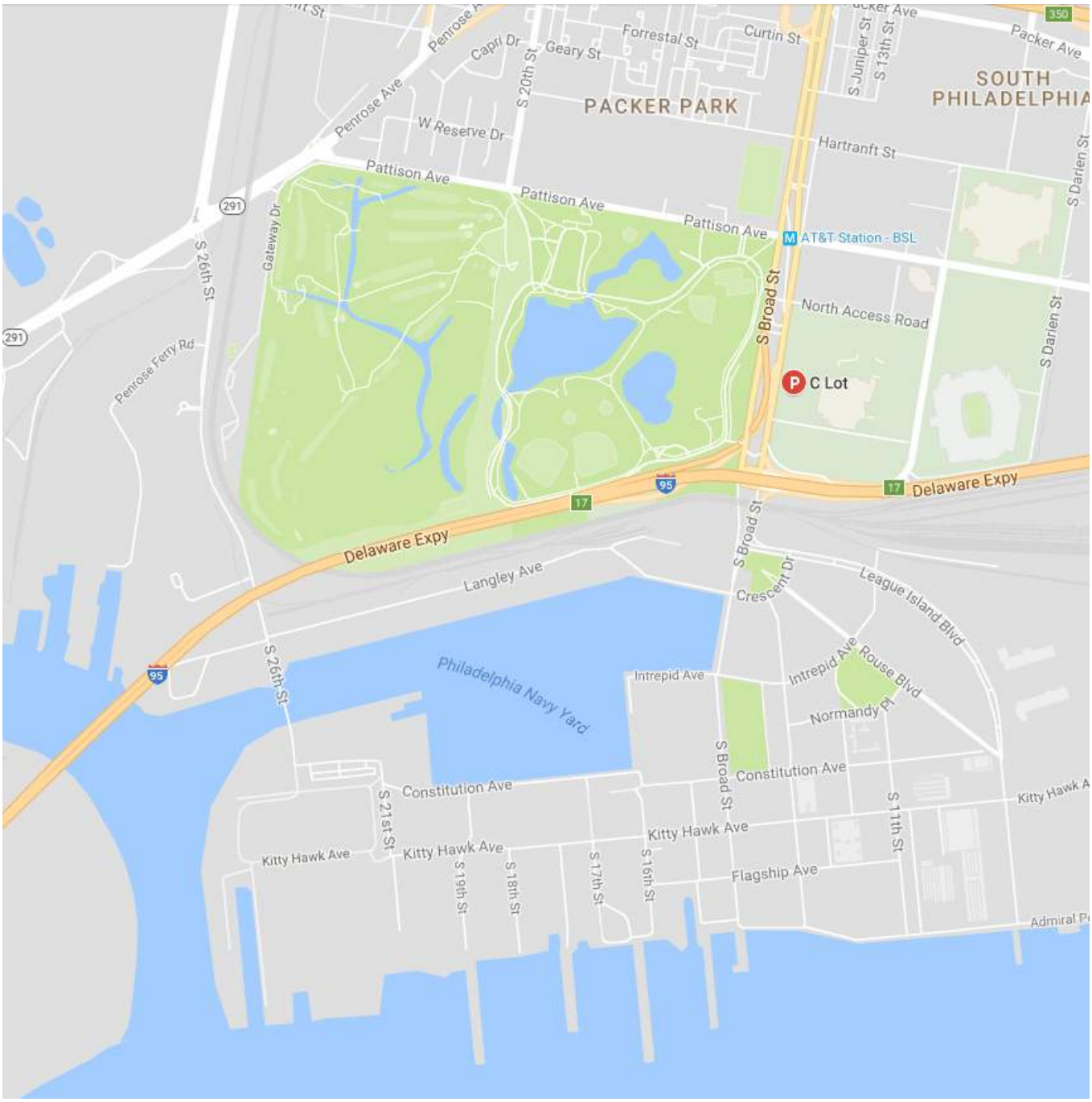
Source: PIDC, 2016

**Figure 6: Existing (2013) On Street Parking in Navy Yard**



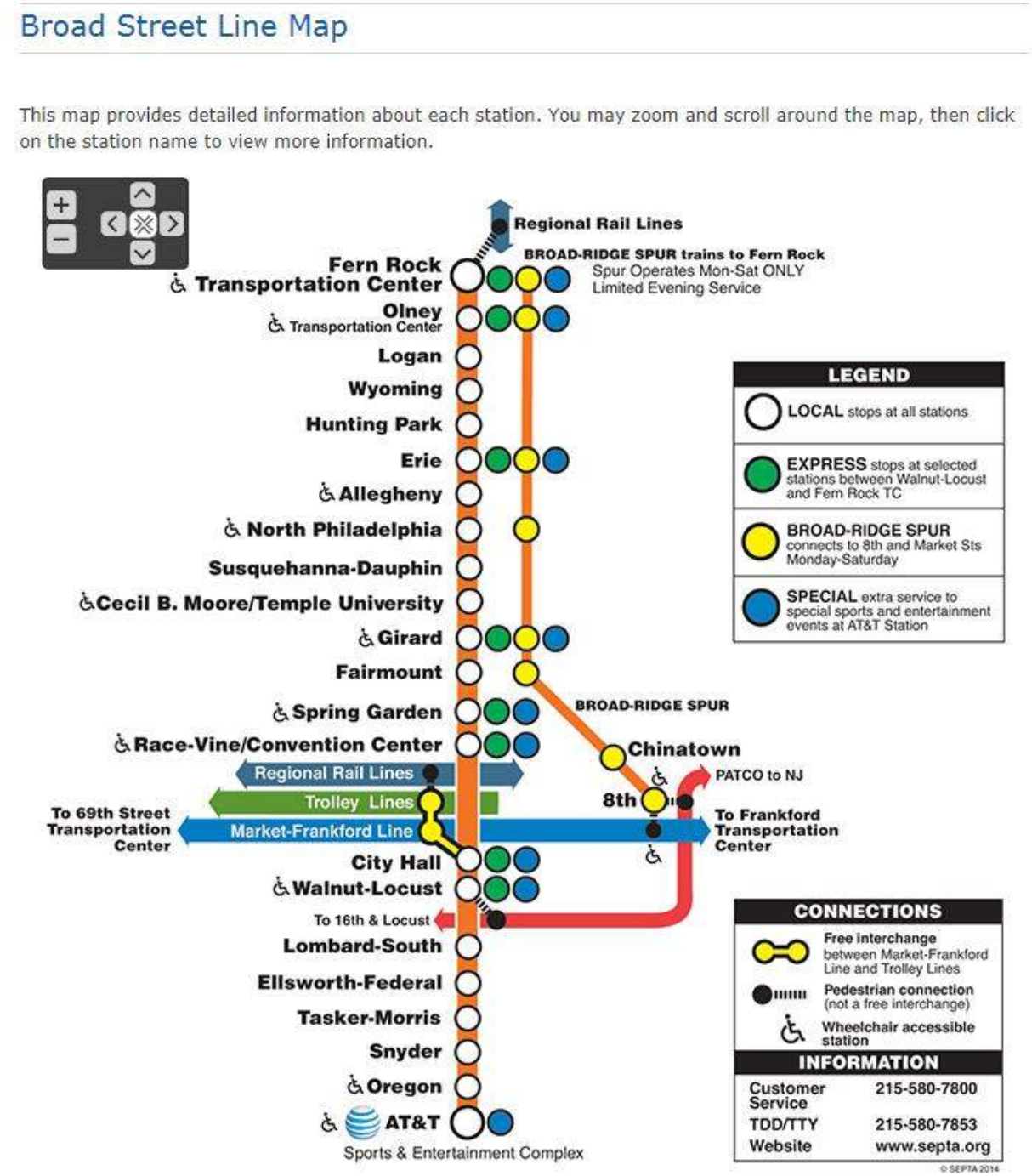

Source: PIDC, 2016

**Figure 7: Existing (2013) Park & Ride Lot at Stadium Complex**




Source: Google Maps, 2017

**Figure 8: Broad Street Subway Line**




Source: SEPTA, 2017

**Figure 9: PIDC Loop Shuttle**


Source: PIDC, 2015

**Figure 10: PIDC Express Shuttle**


Source: PIDC, 2015

## Validation

The validation process involved comparing the Base year model to various transportation data sources, to check whether the model is performing within accepted industry standards and guidelines[2]. The Base year for this analysis is 2013. This was the most recent year for which roadway traffic volumes, transit ridership, travel times, and other validation data was available at the start of the study.

One of the major data sources was a survey of Navy Yard employees that was conducted in the Fall of 2015. Although the data was not collected in 2013, it is still close enough to be considered of value for the validation process. The survey asked employees for basic information about their daily commute. For example, their home and work locations, their mode of travel (auto, transit, bike, or walk) and how long (in minutes) it usually takes them to travel to work. Approximately 1,000 complete and valid responses were received, about 10 percent of the total number of employees.

The survey results are shown in **Figures 11, 12 and 13**. As can be seen in **Figure 11**, although Navy Yard workers are distributed throughout the region, they tend to be concentrated in several neighborhoods in the urban area. In particular, South Philadelphia and the neighborhoods located immediately north of Center City.

**Figure 12** shows the commute times for employees, across all travel modes. The median commute is between 30 and 35 minutes. There are many employees (25%) who live within 20 minutes of work.

**Figure 13** shows how employees are currently commuting to the Navy Yard. As can be seen, most employees (69%) are currently commuting to work by auto. This partly reflects the abundance of free parking in the Navy Yard. As for other modes, 28% are currently using some form of public transit to commute to the Navy Yard, 3% bike to work, and 0% walk.

**Figure 14** shows the two screen lines that were used for model validation. A screen line represents a sequence of locations that define a natural or man-made barrier where the counting of crossing vehicles can be readily accomplished. Downtown Philadelphia has a grid street network and the Center City South screenline cuts across the north-south streets just south of Center City, parallel to South Street. **Table 2** compares the traffic count data to the roadway volumes as estimated by the model at these screenlines. As shown, on a typical weekday in 2013, there were approximately 256,000 vehicles that crossed the Center City South screenline. The model estimates a daily flow of 277,780 vehicles, about 8% higher than the count data.

The second screenline cuts across the two streets (Broad Street and South 26$^{th}$ / Basin Bridge Street) that provide access to the Navy Yard. Approximately 20,400 vehicles enter and exit the Navy Yard on a typical weekday via these two roads, with most of this traffic (83%) using Broad Street (although trucks are prohibited from using Broad). The model estimates 20,650 vehicles entering and exiting per day, only 1% higher than the count. The model is well within accepted levels of deviation at both screenlines.

**Figure 15** shows the origin of work trips to the Navy Yard as estimated by the model. Compared to **Figure 11**, the same data from the employee survey, one can see how the model is providing a more complete picture – it shows origins for the total number of employees. Whereas the survey is only showing the origins

[2] Federal Highway Administration. *Travel Model Validation and Reasonableness Checking Manual, Second Edition*. September 24, 2010. http://media.tmiponline.org/clearinghouse/FHWA-HEP-10-042/FHWA-HEP-10-042.pdf

for a fraction of the worker population, and therefore, there are quite a few more TAZs with 0 respondents in **Figure 11**.

Although the percentage of worker trips coming from any particular TAZ may differ between the survey and the model, many of the same neighborhoods are showing up as high concentrations of worker origins. These include South Philadelphia, Northern Liberties / Fishtown, and the Fairmount / Ben Franklin Parkway area. **Figure 15** also shows high concentrations of employees coming from the TAZs along the subway (MFL and BSL) and regional rail lines (Chestnut Hill, Norristown, Trenton, and Wilmington).

**Table 3** compares the commute travel times as reported by Navy Yard workers who drive to work, to the travel times for the same trip as calculated by the model. One issue with the survey data is that there were many instances where workers coming from the same location (e.g., with a home location in the same TAZ), reported very different average travel times to work. This might be due to employees taking different routes to work, especially for the employees that live further away from the Navy Yard and have multiple travel options.

To increase the credibility and validity of the analysis, we only did the comparison between model and survey data for home TAZs with 2 or more survey responses that all reported the same travel time to the Navy Yard. Based on this criteria, the greatest number of responses were for employees who reported commute travel times between 10 and 15 minutes, and between 15 and 20 minutes, e.g., for the employees living relatively close to work. And for these relatively short commutes, the model matches respondent commute times 100% of the time.

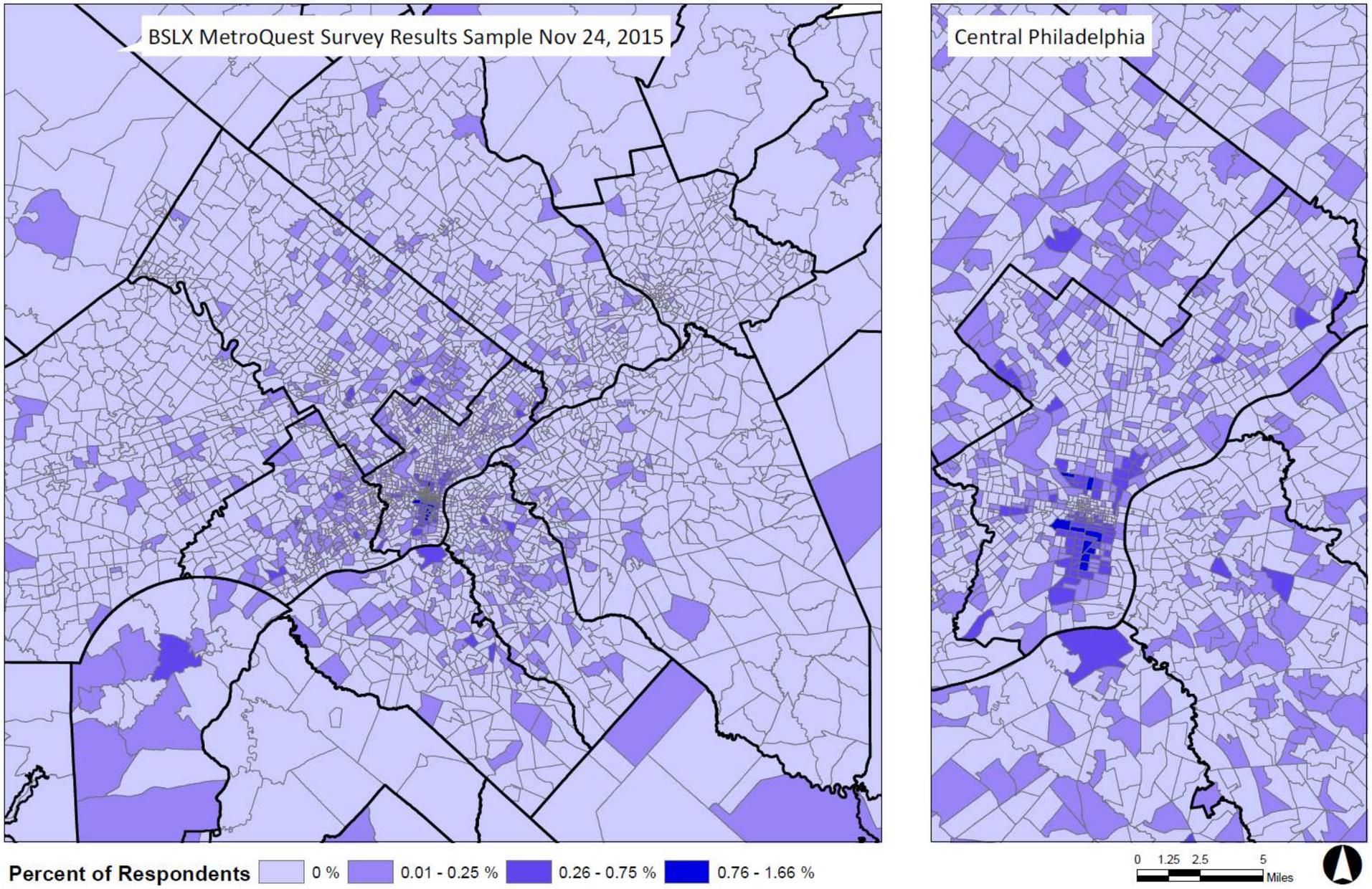
In terms of public transit ridership, **Table 4** focuses on the major transit routes serving the study area. Based on the survey, most employees who commute to the Navy Yard by transit use the Broad Street Subway and transfer to the Loop Shuttle at AT&T Station (71% of transit riders). Approximately 26% take the Express Shuttle from Center City (approximately half transfer to the Express from another transit route).

As shown in **Table 4**, the Broad Street Subway line dwarfs the bus routes in terms of passengers carried per day. The model slightly underestimates (-4.1%) daily ridership on the subway line, and is within 10% to 30% of the count for Route 4 and the Loop and Express shuttles. The model is not as accurate at predicting ridership on Route 68 (-65.0%). But this bus route has relatively low ridership, and the allowable level of deviation is much higher for routes like this. Overall, when compared to all six subway and bus routes, the model is only off by -3.1%.

Finally, **Table 5** shows daily boardings and alightings at the Broad Street Subway Line stations that are most likely to be used by current passengers from the study area. The model varies quite a bit from station to station. For example, it is 7% low at Oregon, and 15% high at AT&T. But again, when comparing the total across these eight stations the model does a very good job of matching the count data (-9%). And considering that the data is from 2014, while the model represents 2013 conditions, it makes sense that the model would be a little low.

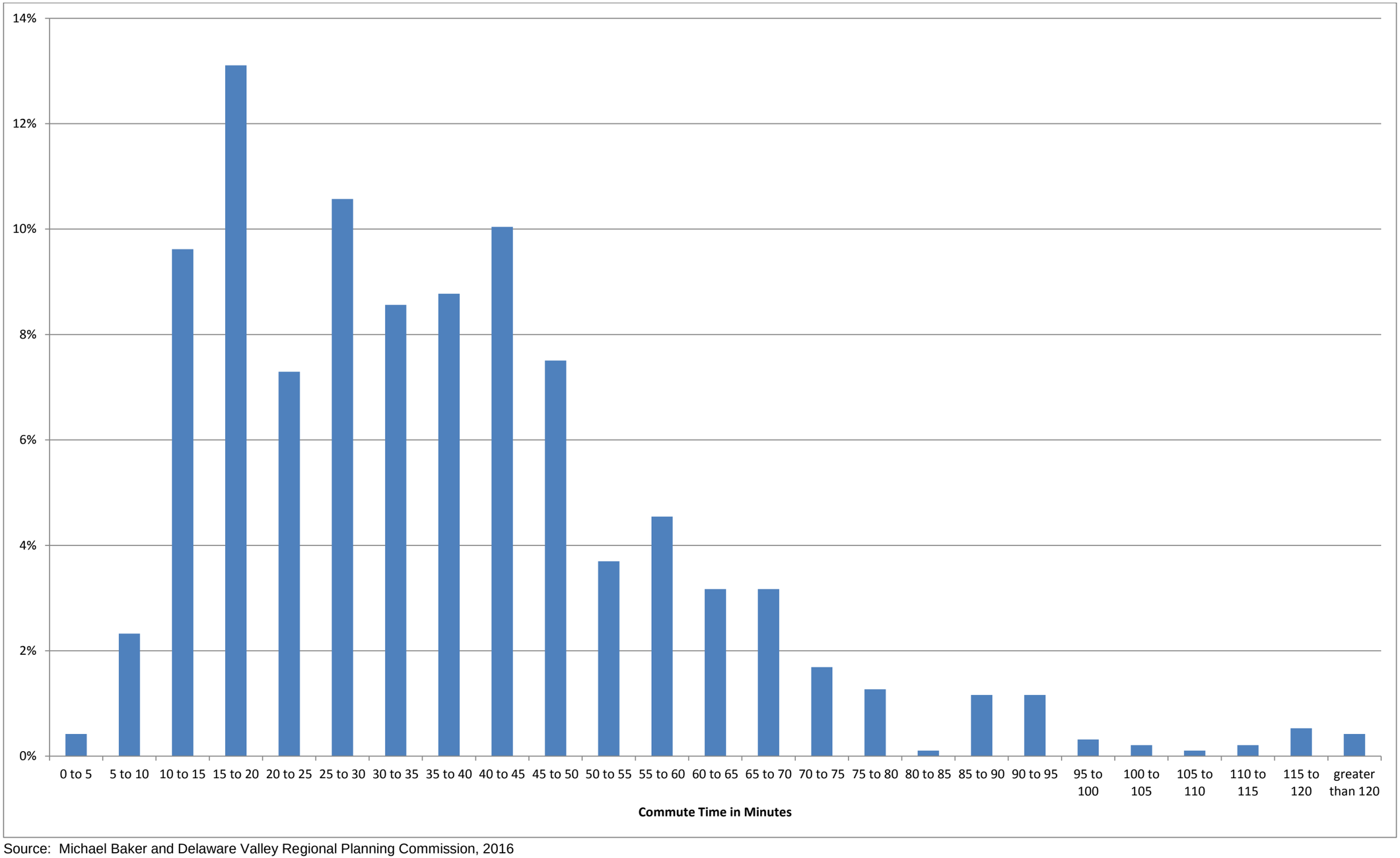
In conclusion, when considering all of the above, the model appears to be performing well. The model is never able to exactly match the count on any specific roadway, or bus route, or at any specific station. But that is to be expected. No model is able to do that. The real question is whether the model can come within generally accepted guidelines for allowable deviation. And this model is definitely able to do that.

**Figure 11: Navy Yard Employee Origins from Survey**



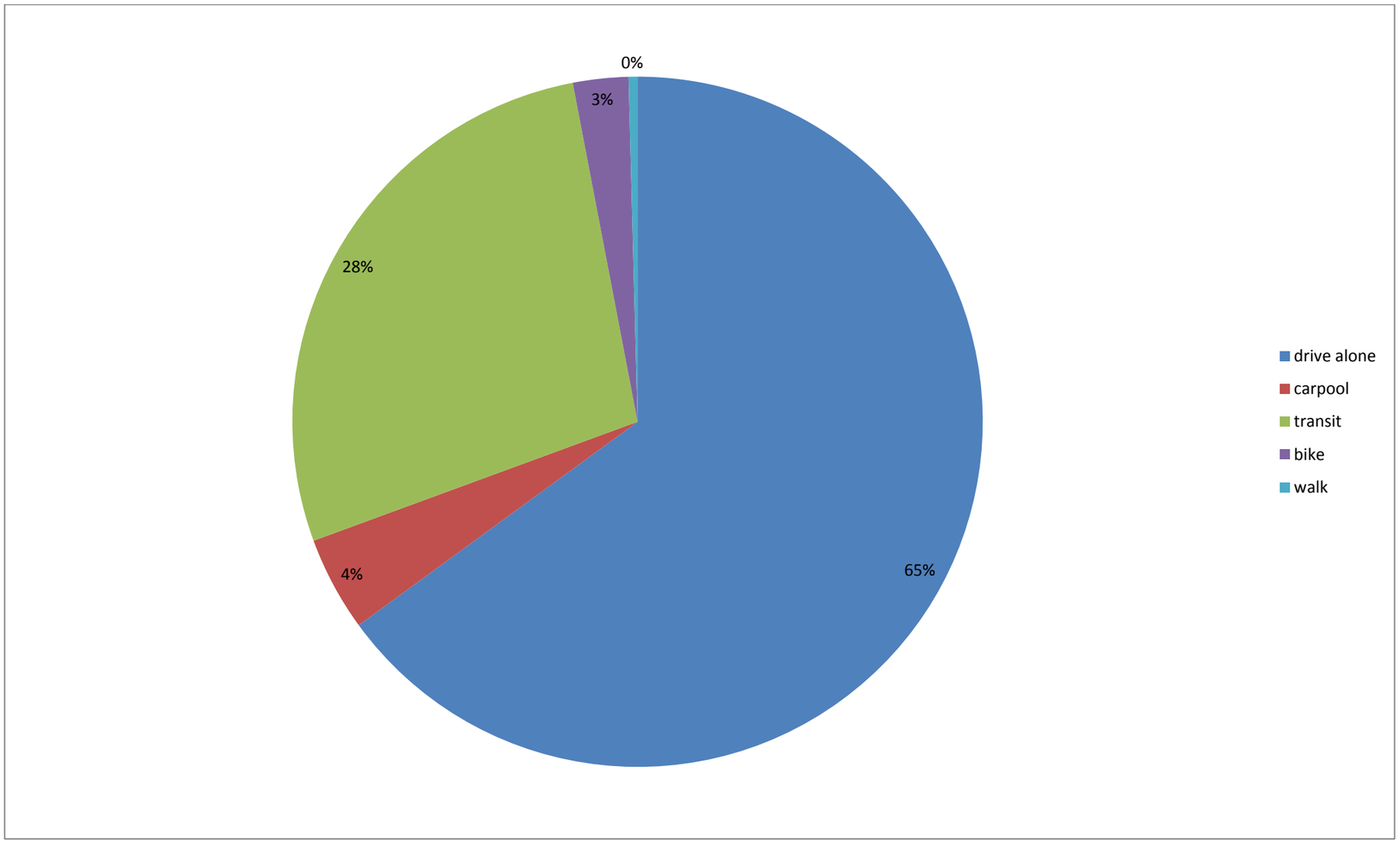

Source: Michael Baker and Delaware Valley Regional Planning Commission, 2016

**Figure 12: Navy Yard Employee Commute Times (all modes)**



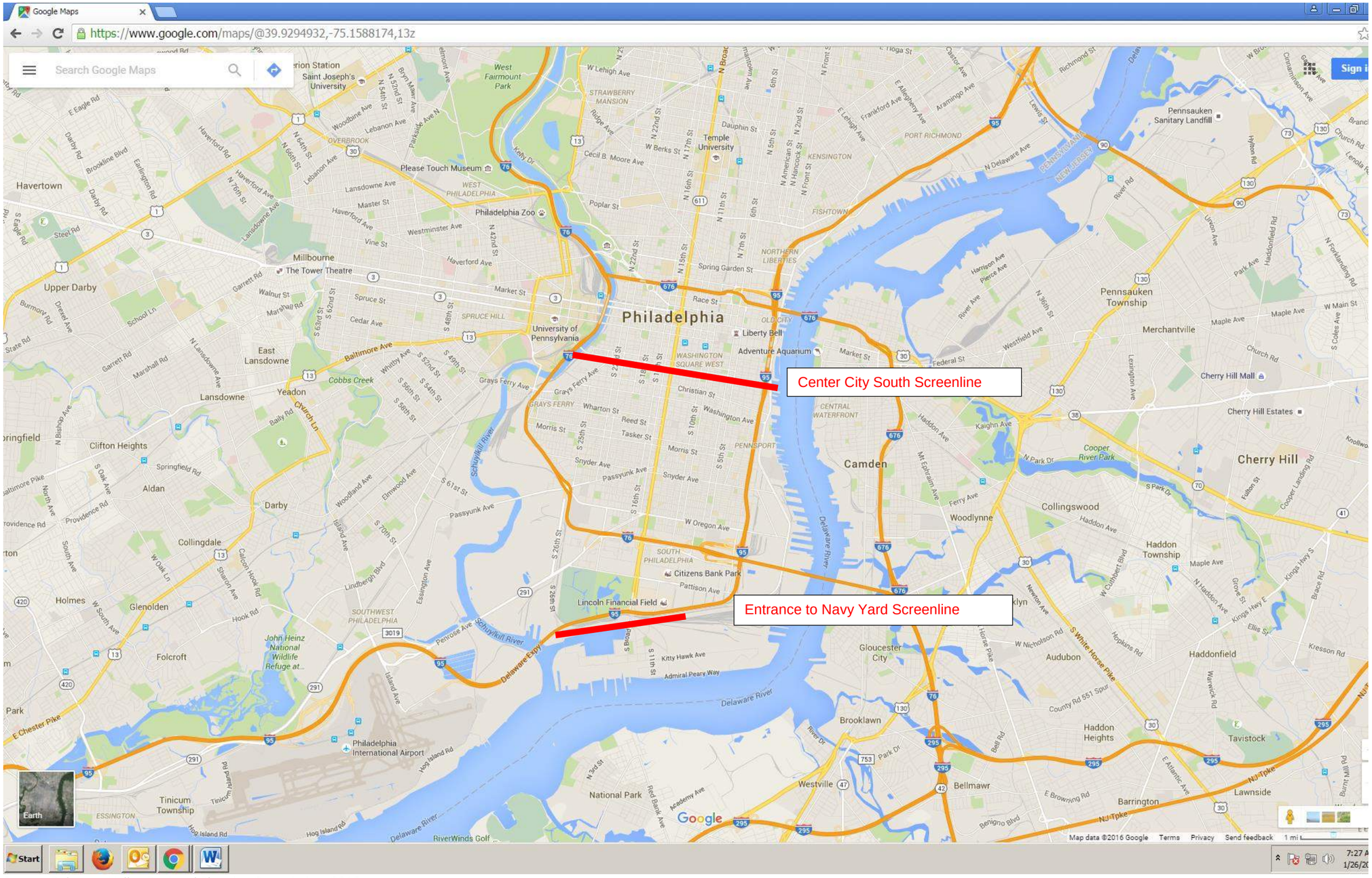

Source: Michael Baker and Delaware Valley Regional Planning Commission, 2016

**Figure 13: Navy Yard Employee Commute Mode Split**




Source: Michael Baker and Delaware Valley Regional Planning Commission, 2016

**Figure 14: Roadway Screen Lines**




Source: Delaware Valley Regional Planning Commission, 2016

**Table 2: Roadway Screenlines**

| Screenline | Road | Direction | Daily Count (2010, 2015) | Daily Model Volume (2013) | Difference | % Difference |
|---|---|---|---|---|---|---|
| Entrance to Navy Yard | Broad Street | North | 8,500 | | | |
| | | South | 8,400 | | | |
| | | Total | 16,900 | 17,150 | +250 | +1% |
| | | | | | | |
| | South 26th Street / Basin Bridge Road | North | 1,780 | | | |
| | | South | 1,770 | | | |
| | | Total | 3,550 | 3,500 | -50 | -1% |
| | | | | | | |
| | SCREENLINE TOTAL | | 20,450 | 20,650 | 200 | +1% |
| | | | | | | |
| Center City South | | North | 126,680 | | | |
| | | South | 129,610 | | | |
| | | | | | | |
| | SCREENLINE TOTAL | | 256,290 | 277,780 | 21,490 | +8% |

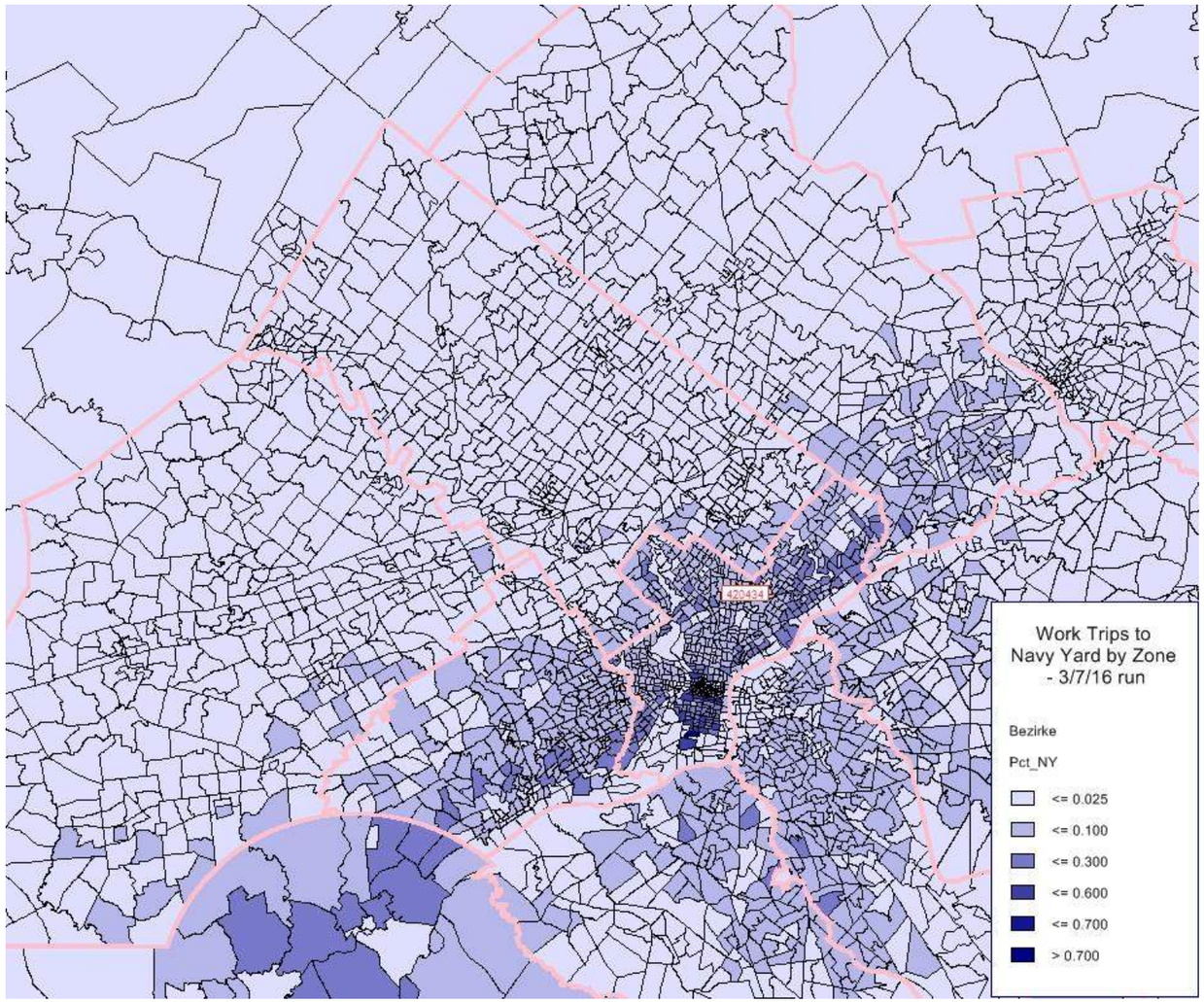
Source: Delaware Valley Regional Planning Commission, 2016
Counts taken at entrance to Navy Yard in January 2015
Counts taken at Center City South screenline in October and November of 2010

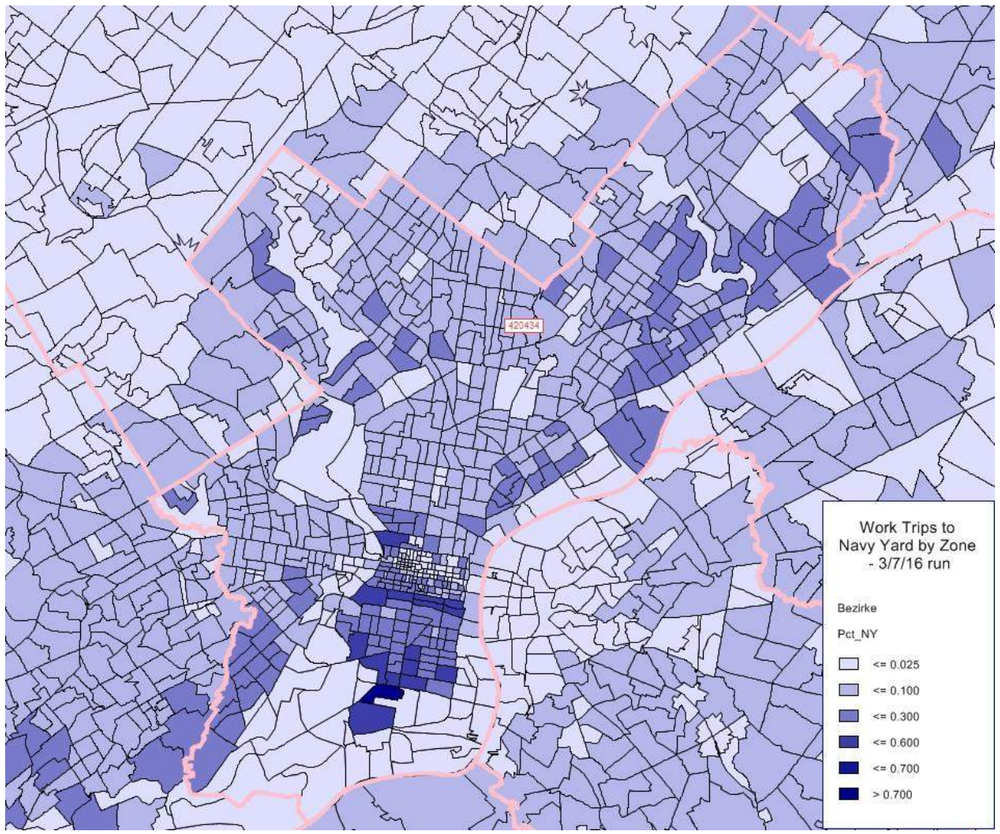
**Table 3: Highway Travel Time Check (for Auto trips)**

| | Respondent travel time (in minutes) | # of responses | Number where respondent matches Google | Number where model matches Google |
|---|---|---|---|---|
| | | | | |
| People who live close to Navy Yard | 5-10 | 3 | 33% | 33% |
| | 10-15 | 10 | 100% | 100% |
| | 15-20 | 20 | 100% | 100% |
| | | | | |
| People who live further away | 20-25 | 5 | 60% | 80% |
| | 25-30 | 4 | 100% | 75% |
| | 30-35 | 4 | 100% | 50% |
| | 35-40 | 2 | 100% | 100% |
| | 40-45 | 5 | 100% | 60% |
| | 45-50 | 5 | 60% | 60% |
| | 50-55 | 4 | 100% | 25% |
| | 55-60 | 4 | 100% | 25% |
| | | | | |
| TOTAL | | | | |

Source: Michael Baker and Delaware Valley Regional Planning Commission, 2016

**Figure 15: Navy Yard Employee Origins from the Model**




Source: Michael Baker and Delaware Valley Regional Planning Commission, 2016

**Table 4: Daily Boardings for Transit Routes Currently Serving the Navy Yard (or most likely to be extended into NY)**

| Route | Daily Count (2013) | Model (2013) | Difference | % Difference | |
|---|---|---|---|---|---|
| SEPTA Route 4 Bus | 7,400 | 6,500 | -900 | -12.2% | Candidate route to extend to Navy Yard |
| | | | | | |
| SEPTA Route 45 Bus | 22,800 | 25,000 | 2,200 | 9.6% | Most likely bus route to extend to Navy Yard (in 2016, it gets split into Routes 23 and 45) |
| | | | | | |
| SEPTA Route 68 Bus | 1,000 | 350 | -650 | -65.0% | Serves TastyKake bakery at 4300 South 26th Street |
| | | | | | |
| SEPTA Broad Street Line (BSL) Subway | 127,000 | 121,740 | -5,260 | -4.1% | |
| | | | | | |
| Loop Shuttles (PIDC + URBN + Healthmark) | 850 | 730 | -120 | -14.1% | |
| | | | | | |
| Express Shuttle (PIDC) | 750 | 540 | -210 | -28.0% | |
| | | | | | |
| TOTAL | 159,800 | 154,860 | -4,940 | -3.1% | |

Source: SEPTA Route Statistics Report, 2014 and Delaware Valley Regional Planning Commission, 2016

**Table 5: Broad Street Subway Line Average Weekday Boards + Alights by Station**

| Station | Daily Count (2014) | Model (2013) | Difference | % Difference |
|---|---|---|---|---|
| City Hall | 68,590 | 55,730 | -12,860 | -19% |
| Walnut-Locust | 14,602 | 16,750 | 2,148 | 15% |
| Lombard-South | 6,291 | 7,330 | 1,039 | 17% |
| Ellsworth-Federal | 6,327 | 4,360 | -1,967 | -31% |
| Tasker-Morris | 8,638 | 8,310 | -328 | -4% |
| Snyder | 11,338 | 11,570 | 232 | 2% |
| Oregon | 7,158 | 6,680 | -478 | -7% |
| AT&T / Pattison Ave | 2,805 | 3,230 | 425 | 15% |
| | | | | |
| TOTAL | 125,749 | 113,960 | -11,789 | -9% |

Source: Count data from Broad Street Line Ridership Census 2014, SEPTA

## 2040 No Build Scenario

DVRPC's existing 2040 model was used to develop the future year scenarios. The 2040 No Build scenario includes all of the land use growth from the 2013 Base to 2040, as well as any planned highway and transit improvements, except for the Broad Street Subway Line Extension project.

### Future Year Land Use

The future year land use is based on DVRPC's Board adopted 2040 Long Range Plan. DVRPC met with project stakeholders during the Summer of 2015 to confirm where projected growth is anticipated to occur, and in roughly what time frame, and by how much. DVRPC also used enhanced commercial real estate data[3] and the Navy Yard Master Plan[4] to identify future land use development that is proposed and/or currently under construction. These information sources were used to refine and revise the 2040 forecasted land use where necessary.

**Table 6** shows the 2040 land use for the TAZs located in the Navy Yard, and the rest of the Lower South District. Compared to the same data for 2013 (

**Table** 1), the Navy Yard is projected to experience considerable growth during the 27 years between 2013 and 2040 (shown in **Table 7**). Currently there is no residential population at the Navy Yard. However, by 2040 this is expected to increase to 1,609 residents and 1,070 households. In terms of employment, the current number of employees is projected to almost triple, from 9,900 to 28,175.

Growth is also expected to occur in several zones in the rest of the Lower South District, although at much lower levels than in the Navy Yard. For example, the Packer Park area (TAZ 1816) is projected to see an increase in population of 1,338 residents. Also, the Stadiums complex (TAZ 1814) is expected to see an increase of approximately 1,000 employees.

[3] CoStar Group. http://www.costar.com/Products/
[4] PIDC, http://www.navyyard.org/about-the-campus/master-plan/

**Table 6: 2040 Land Use for the Navy Yard, and Lower South District**

| TAZ | Location | | Population | Households | | Employment |
|---|---|---|---|---|---|---|
| | | | | <=$35,000 | >$35,000 | |
| 1801 | Navy Yard | | 0 | 0 | 0 | 1,283 |
| 1802 | Navy Yard | | 0 | 0 | 0 | 3,961 |
| 1803 | Navy Yard | | 271 | 98 | 92 | 3,804 |
| 1804 | Navy Yard | | 1,338 | 453 | 427 | 12,415 |
| 1805 | Navy Yard | | 0 | 0 | 0 | 4,137 |
| 1806 | Navy Yard | | 0 | 0 | 0 | 1,625 |
| 1807 | Navy Yard | | 0 | 0 | 0 | 950 |
| | | Sub-Total | 1,609 | 551 | 519 | 28,175 |
| | | | | | | |
| 1808 | CSX Intermodal | | 5 | 3 | 0 | 99 |
| 1809 | | | 0 | 0 | 0 | 26 |
| 1810 | Packer Ave Marine Terminal | | 0 | 0 | 0 | 546 |
| 1811 | FDR Park | | 1,567 | 573 | 427 | 108 |
| 1812 | Whiskey Yard | | 0 | 0 | 0 | 2 |
| 1813 | Food Distribution | | 0 | 0 | 0 | 3,300 |
| 1814 | Stadiums | | 0 | 0 | 0 | 3,097 |
| 1815 | | | 0 | 0 | 0 | 232 |
| 1816 | Packer Park | | 5,374 | 917 | 1,527 | 428 |
| 1817 | | | 270 | 13 | 7 | 367 |
| 1818 | | | 0 | 0 | 0 | 778 |
| 1819 | Sunoco | | 3 | 10 | 0 | 29 |
| 1820 | CSX Transflo | | 0 | 0 | 0 | 4 |
| 1821 | | | 10 | 10 | 5 | 189 |
| 1822 | | | 430 | 187 | 63 | 795 |
| | | Sub-Total | 7,659 | 1,713 | 2,029 | 10,000 |
| | | | | | | |
| | | **Lower South Total** | **9,268** | **4,812** | | **38,175** |

Source: Delaware Valley Regional Planning Commission, 2016

**Table 7: 2013 - 2040 Change in Land Use**

| TAZ | Location | | Population | Households <= $35,000 | Households >$35,000 | Employment |
|---|---|---|---|---|---|---|
| 1801 | Navy Yard | | 0 | 0 | 0 | 181 |
| 1802 | Navy Yard | | 0 | 0 | 0 | 1,461 |
| 1803 | Navy Yard | | 271 | 98 | 92 | 3,794 |
| 1804 | Navy Yard | | 1,338 | 453 | 427 | 8,505 |
| 1805 | Navy Yard | | 0 | 0 | 0 | 3,793 |
| 1806 | Navy Yard | | 0 | 0 | 0 | 360 |
| 1807 | Navy Yard | | 0 | 0 | 0 | 181 |
| | | Sub-Total | 1,609 | 551 | 519 | 18,275 |
| | | | | | | |
| 1808 | CSX Intermodal | | 1 | 3 | 0 | -51 |
| 1809 | | | 0 | 0 | 0 | -4 |
| 1810 | Packer Ave Marine Terminal | | 0 | 0 | 0 | 95 |
| 1811 | FDR Park | | 442 | 177 | 144 | 58 |
| 1812 | Whiskey Yard | | 0 | 0 | 0 | -198 |
| 1813 | Food Distribution | | 0 | 0 | 0 | 601 |
| 1814 | Stadiums | | 0 | 0 | 0 | 997 |
| 1815 | | | 0 | 0 | 0 | 32 |
| 1816 | Packer Park | | 1,338 | 280 | 444 | 8 |
| 1817 | | | 238 | 3 | 5 | 7 |
| 1818 | | | 0 | 0 | 0 | 3 |
| 1819 | Sunoco | | 1 | 8 | 0 | -1 |
| 1820 | CSX Transflo | | 0 | 0 | 0 | -46 |
| 1821 | | | 3 | 7 | 5 | 14 |
| 1822 | | | 100 | 58 | 25 | 85 |
| | | Sub-Total | 2,123 | 536 | 623 | 1,600 |
| | | | | | | |
| | | **Lower South Total** | **3,732** | **2,229** | | **19,875** |

Source: Delaware Valley Regional Planning Commission, 2016

## Future Year Highway Network

**Table 9** shows the planned projects for South Philadelpia, in and around the Navy Yard. **Figure 16** shows the future roadway network, color coded by the number of lanes in each direction. Several roadway improvements were made between the 2013 Base Year network shown in **Figure 4**, and the 2040 Future Year network:

- Widening of South Broad Street, from Crescent Drive to Kitty Hawk Avenue, from two to four lanes.

- Completion of the roads serving the new / proposed development in the Navy Yard. Most notably the extension of Rouse Boulevard all the way to League Island Boulevard, and the addition of the following new roads: Mustin Road, Mustin Park West, Mustin Park East, West Canal Street, and East Canal Street.

- Re-construction and re-alignment of Langley Avenue[5].

  This project consists of all phases from preliminary and final design to re-construction of Langley Avenue access road from 26th Street to Broad Street adjacent to the Navy Yard reserve basin. This project will improve safety and access from the west to the east side of the Navy Yard. This project includes the reconstruction of the roadway and installation of new curbs, curb cuts, sidewalks and streetscaping features along the existing Langley Avenue and the eastern half of the existing Broad Street from Langley to Intrepid, while maintaining the existing roadway widths and lane configurations. Langley Avenue will be reconstructed and have a curve straightened to more safely accommodate passing tractor trailers.

## Future Year Transit Network

Both the PIDC Loop and Express shuttle bus routes are expanded in the 2040 No Build.

The Loop shuttle is split into two routes, one traveling in a clockwise direction through the Navy Yard, and the other in a counter-clockwise direction. The two Loops combined complete a total of 60 trips each day, 22 more than the Loop does in the 2013 Base. With more trips, the headways are reduced, from 22 minutes to an average of 13.5 minutes (varies between 12 and 15 minutes).

The Express shuttle service increases from 36 to 48 trips per day. Average headway during the AM peak is 10 minutes, and 12 minutes during the PM peak. Travel time from Center City (10th and Market) to the Navy Yard (League Island & Crescent Drive) is 31 minutes during the AM peak.

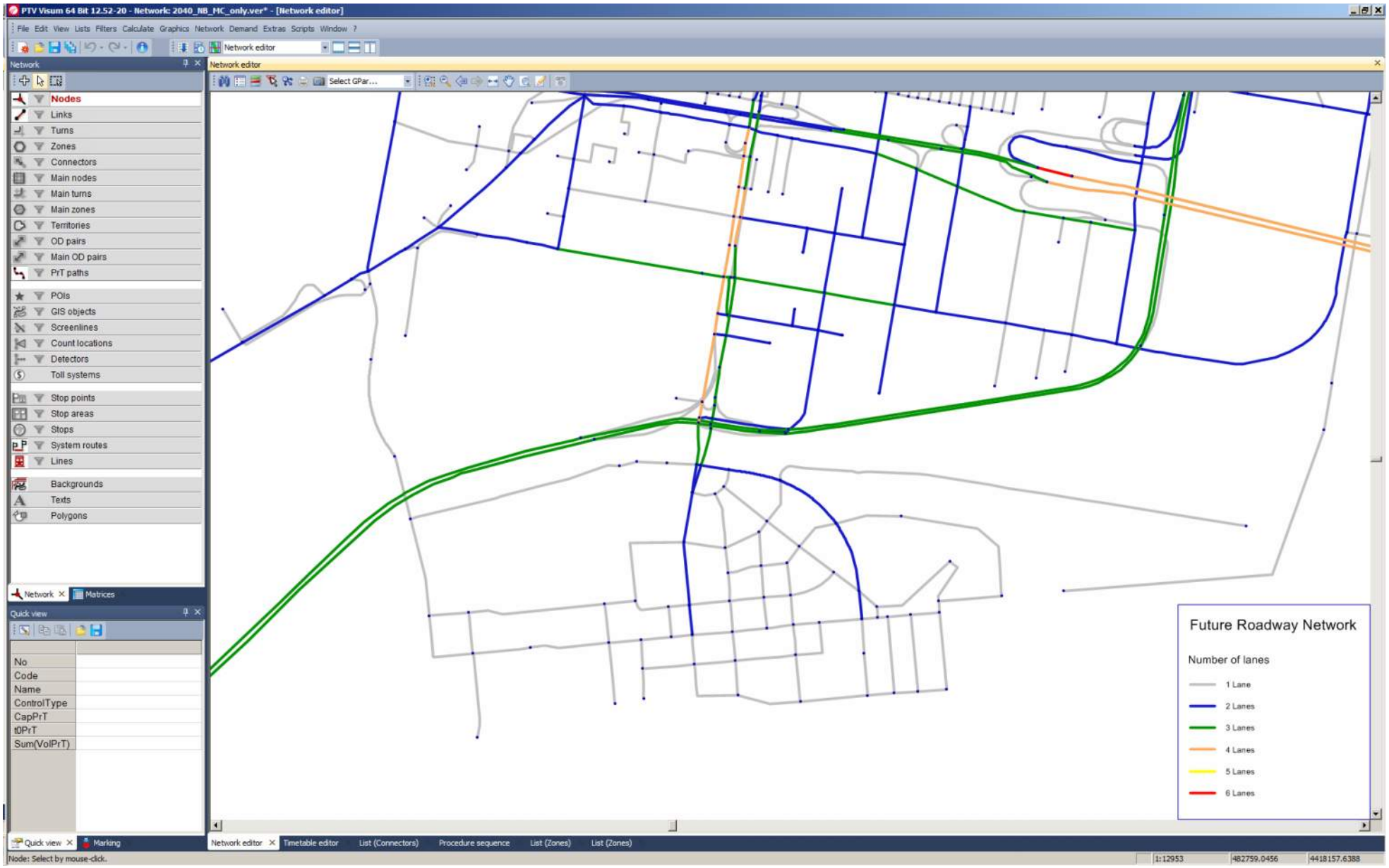
[5] Delaware Valley Regional Planning Commission. *FY2017 Transportation Improvement Program (TIP) for Pennsylvania*. MPMS 46958 – Philadelphia Naval Shipyard Access. https://www.dvrpc.org/asp/TIPsearch/2017/PA/

**Table 8: Planned Roadway Improvements - Future Year Regionally Significant Roadway projects added between 2013 and 2040**

| Project # | Description | Year added |
|---|---|---|
| Privately funded | South Broad Street, widen from 2 to 4 lanes, from Crescent Drive to Kitty Hawk Avenue | 2018 |
| | | |
| MPMS 46958 | Navy Yard Access improvements, re-construction and re-alignment of Langley Avenue | 2020 |
| | | |
| MPMS 102839 | South Philadelphia Neighborhood Bikeway | 2020 |
| | | |
| MPMS 62694 | Passyunk Avenue Drawbridge over the Schuylkill River Rehabilitation | 2020 |
| MPMS 16987 | Passyunk Avenue Signal Improvements | 2020 |
| | | |
| MPMS 98207 | I-95 Congestion Management | 2020 |
| MPMS 86046 | I-95 Girard Point Bridge Rehabilitation and Preservation | 2020 |
| MPMS 104243 | I-95 Central and South Philadelphia Project Development | 2020 |
| | | |
| LRP | I-95 South Philadelphia, reconstruct / rehabilitate from Queen Street to north of the Girard Point Bridge | 2040 |
| | | |
| LRP | I-476 and I-76 interchange improvements | 2040 |
| LRP | I-476 and I-95, addition of one lane from SB I-476 to SB I-95, and from NB I-95 to NB I-476 | 2040 |
| | | |
| LRP | I-76 reconstruct bridge from Arch St to University Ave; between 34th and Grays Ferry Ave; and over the Schuylkill River | 2040 |
| | | |

Source: Delaware Valley Regional Planning Commission, 2016

**Figure 16: Future (2040) Roadway Network**




Source: Delaware Valley Regional Planning Commission, 2017

## 2040 Build Scenarios

The 2040 Build includes all of the land use growth and assumed network improvements that are included in the 2040 No Build. In addition, the Build also includes the proposed project. There are six different versions, or alternatives, of the 2040 Build. This section describes each Build Alternative, and the key assumptions that were used in the analysis.

### Fixed Trip Table Assumption

The Federal Transit Administration (FTA) administers the New Starts funding program. Transit agencies from across the U.S. seeking funding assistance for their projects compete for these dollars. To be eligible for New Starts assistance, FTA requires agencies to comply with certain guidelines in terms of how they do ridership forecasting. Chief among these is the fixed trip table assumption.

In the past, FTA has received New Starts submittals from applicants and on closer examination of the ridership forecasts discovered that the project sometimes resulted in significant numbers of people changing where they lived and/or worked. In other words, the future year build Home Based Work (HBW) trip table was very different from the future year no build HBW trip table. The end result was higher than normal, or higher than believable ridership forecasts. In reality, most people are probably not going to change where they work simply to be able to ride a new transit line that is built near their home.

Therefore, to counteract this phenomenon, FTA requires that the 2040 Build transit trip table equal the 2040 No Build table. Hence the name, "fixed trip table" assumption. To comply with this requirement, DVRPC implemented a two-step model. Step one involves running the full 2040 No Build model (trip generation, trip distribution, mode split, and assignment) as usual and extracting the trip tables. Step two then involves coding the 2040 Build network, e.g., adding the project, and re-running an abbreviated version (mode split and assignment) of the full model with the No Build trip tables.

### Separating Trips by Income Class

The DVRPC model separates HBW, home based shopping (HBSh), and home based other (HBO) trips by income class. These classes are then aggregated before transit assignment occurs. FTA, however, requires that trips output at the back end of the model after transit assignment also be reported by income-class. This is required because FTA gives extra consideration to lower income (sometimes referred to as "transit dependent") project boardings in the New Starts scoring process. As such, new procedures were needed to separately assign the low-income transit trips from the high-middle income transit trips.

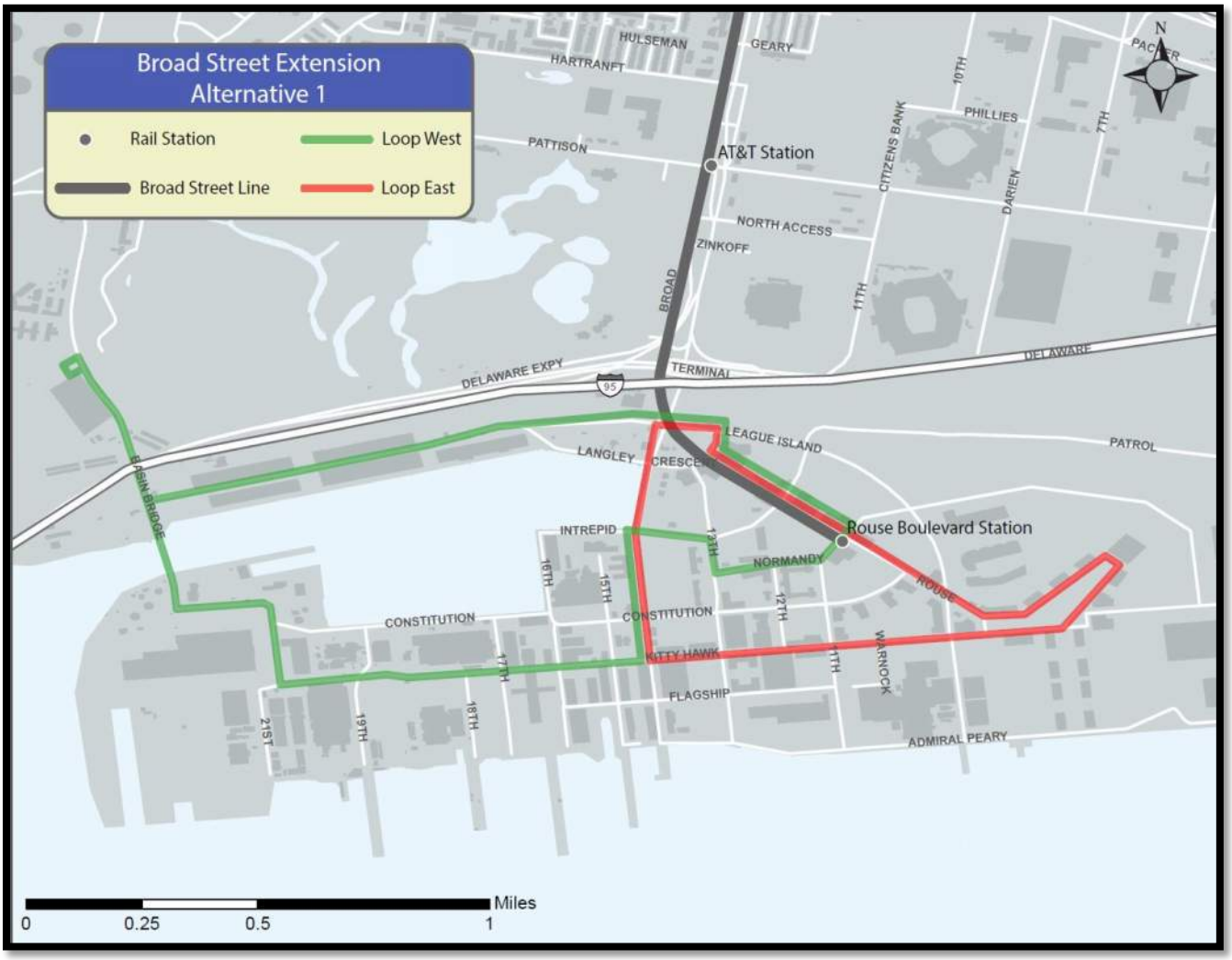
## 2040 Build Alternative 1

This alternative extends the Broad Street Subway line from AT&T station to the Navy Yard as shown in **Figure 17**. There is one new rail station in the Navy Yard on Rouse Boulevard at Central Green. The subway travel time from AT&T Station to Rouse Station is 2 minutes. Travel time from Central City Philadelphia (City Hall) to Rouse Boulevard is 13 minutes.

With the addition of the rail station in the Navy Yard, the subway now provides a direct one-seat ride from Center City. The Express shuttle bus is no longer needed, and is discontinued.

The two Loop shuttle routes are modified. They no longer need to ferry passengers between AT&T station and the Navy Yard. Instead, they are mainly intended to act as feeder routes for the subway extension, for those people who live and work beyond walking distance of the new station.

**Figure 17: Build Alternative 1 – Rail Extension with 1 station at Rouse Boulevard**




Source: HNTB, 2016

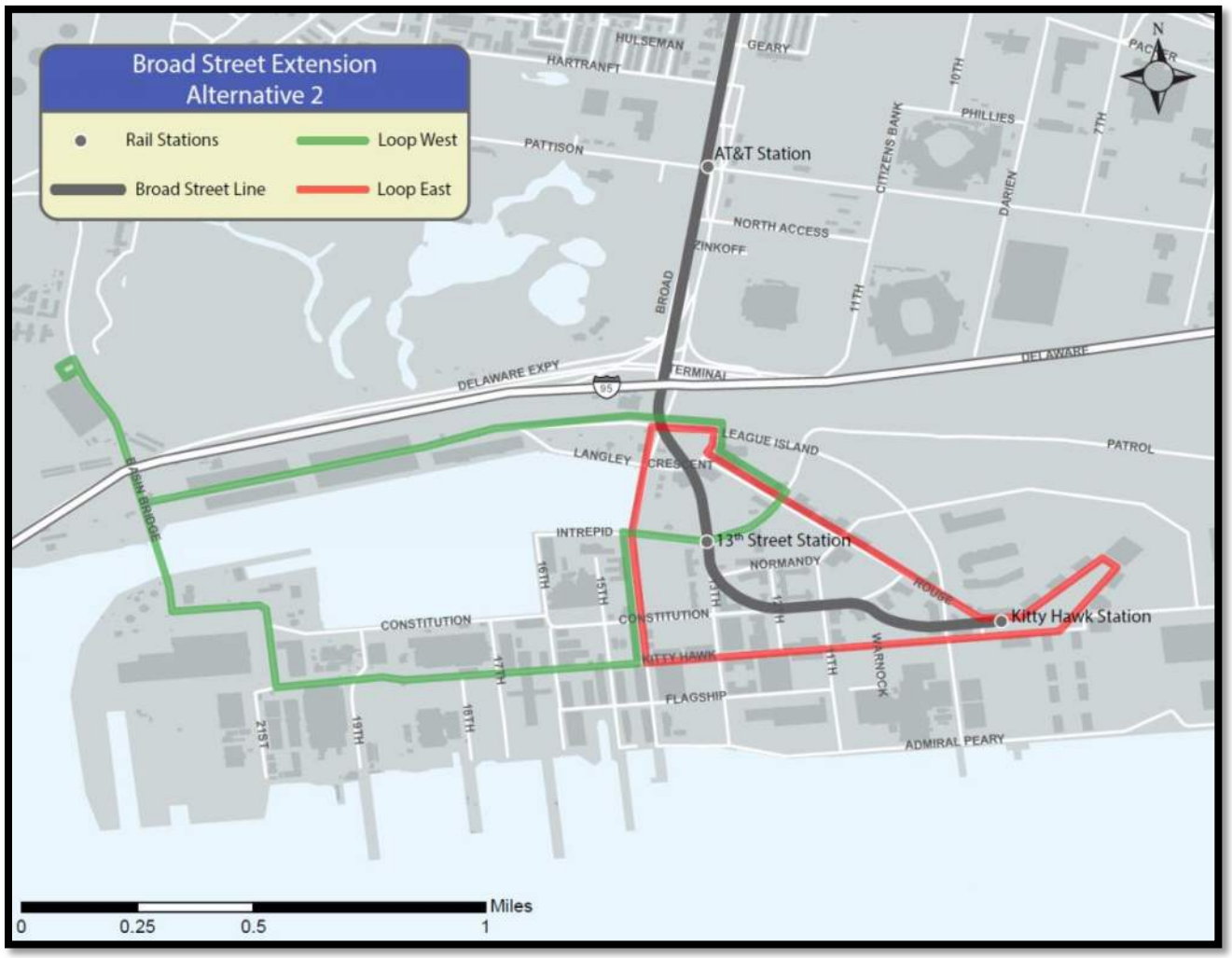
The level of service for the Loop shuttle buses is increased. During the AM, the East Loop (counterclockwise) meets (there is a bus waiting at the station) every inbound train to the Navy Yard arriving at Rouse station, and the West Loop (clockwise) meets every other inbound train. During the PM, the East Loop arrives at Rouse station 2 minutes before every departing outbound train, and the West Loop feeds every other outbound train. The East Loop completes 130 trips per day, and the West Loop completes 65, for a combined total of 195 trips per day, 87 more trips per day than in the 2040 No Build.

In terms of fares, passengers pay the standard SEPTA subway fare to ride the Broad Street Subway to the Navy Yard, but there is no fare to ride the Loop shuttles.

## 2040 Build Alternative 2

This alternative extends the Broad Street Subway line from AT&T station to the Navy Yard as shown in **Figure 18**. There are two new rail stations, at 13th Street and Intrepid Avenue, and at Kitty Hawk Avenue and West Canal Street. The subway travel time from AT&T Station to 13th Street is 2 minutes, and from 13th Street to Kitty Hawk is also 2 minutes.

**Figure 18: Build Alternative 2 - Rail Extension with 2 stations at 13th Street and Kitty Hawk**



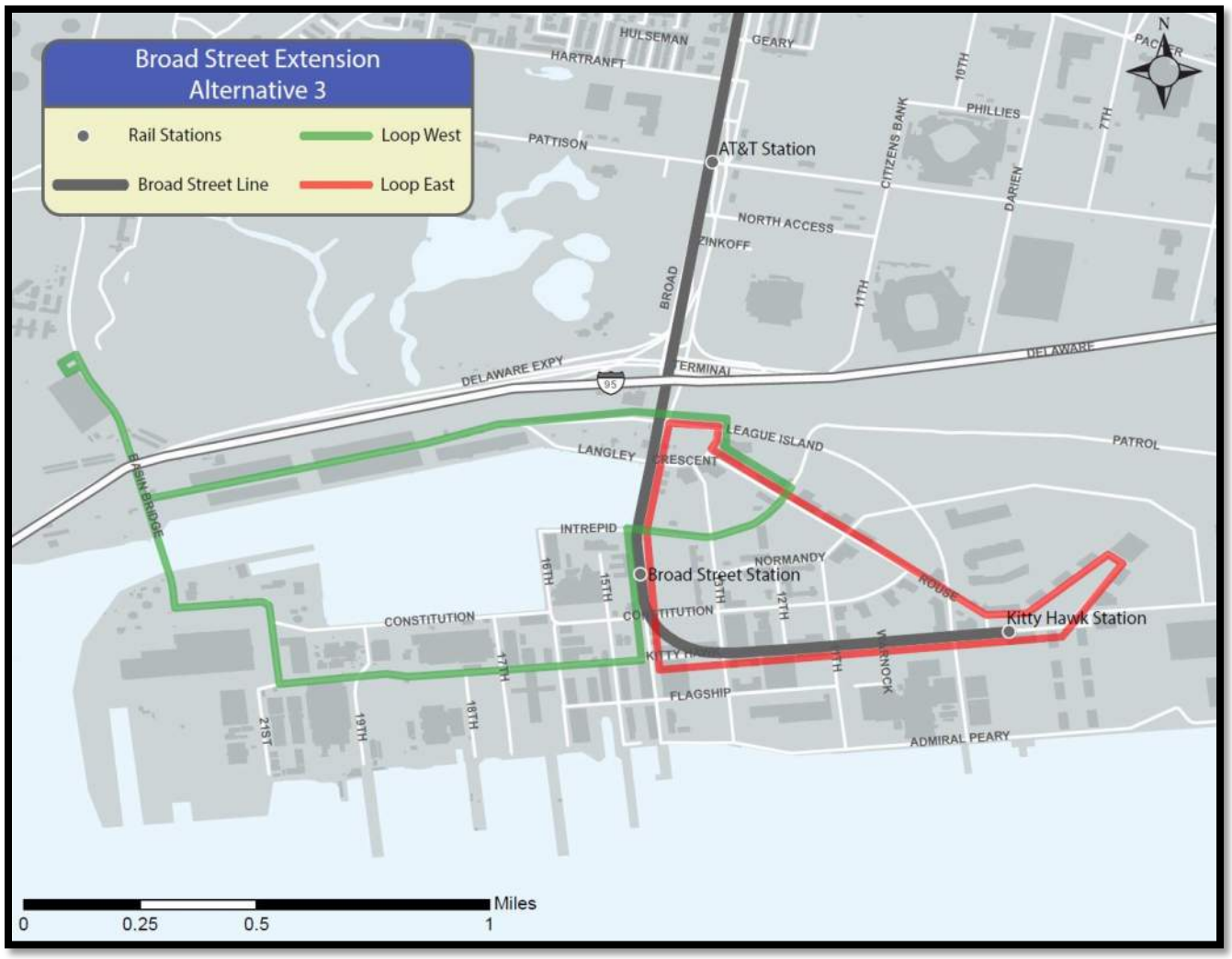

Source: HNTB, 2016

As with Build Alternative 1, the Express Shuttle bus is discontinued, and the two Loop Shuttle routes are modified in the same way.

## 2040 Build Alternative 3

This alternative extends the Broad Street Subway line from AT&T station to the Navy Yard as shown in **Figure 19**. There are two new rail stations, on Broad Street at the Parade Ground, and at Kitty Hawk Avenue and West Canal Street. The subway travel time from AT&T Station to the Parade Ground is 2 minutes, and from the Parade Ground to Kitty Hawk is also 2 minutes.

**Figure 19: Build Alternative 3 – Rail Extension with 2 stations at Broad Street and Kitty Hawk**



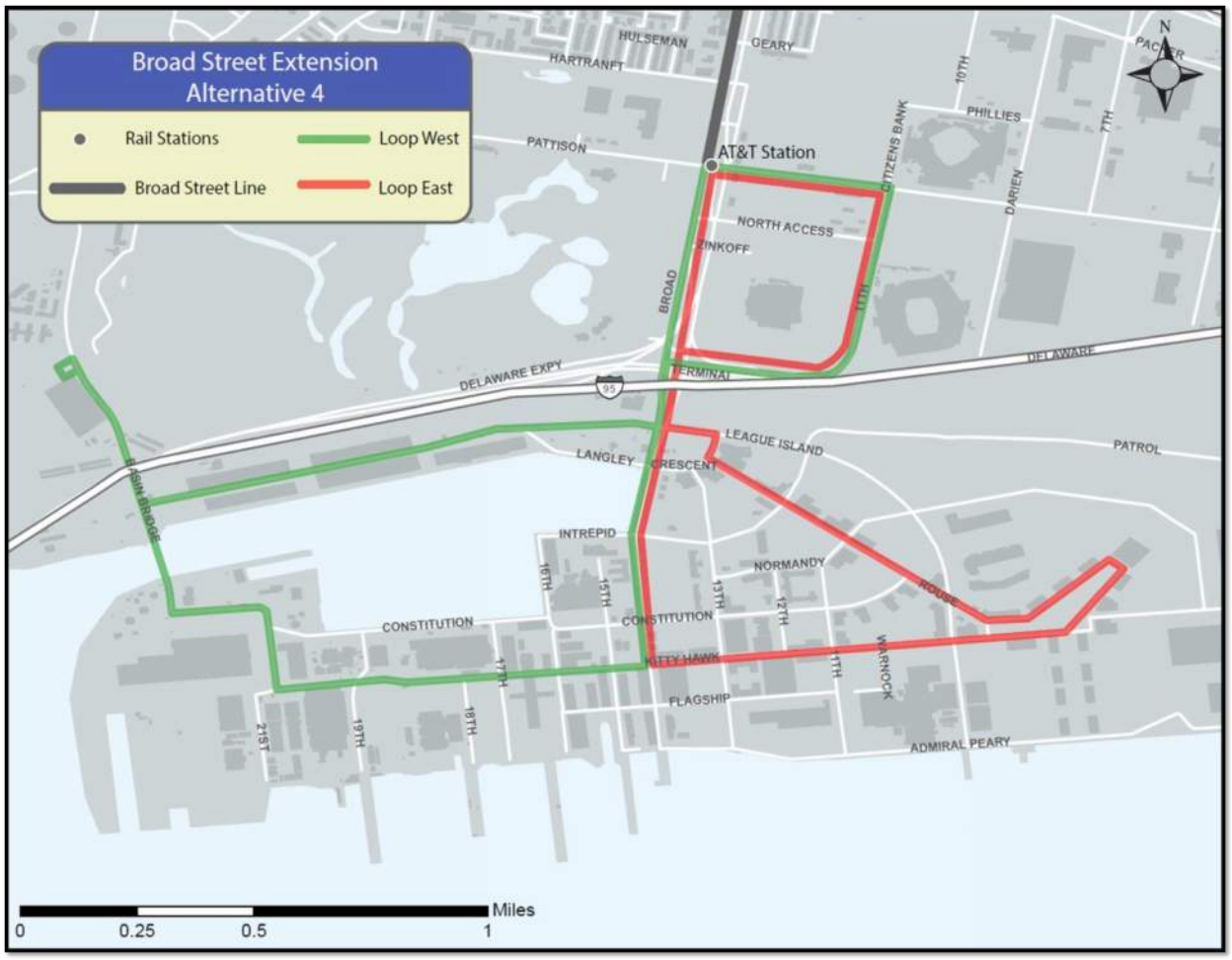

Source: HNTB, 2016

As with Build Alternative 1, the Express Shuttle bus is discontinued, and the two Loop Shuttle routes are modified in the same way.

## 2040 Build Alternative 4

This alternative has the Broad Street Subway line terminating at AT&T Station, and the two Loop shuttle bus routes that were included in Build Alts 1, 2, and 3 being modified to ferry passengers to and from the Navy Yard (**Figure 20**). The Loop shuttles have the same level of service, e.g., a combined total of 195 trips per day. As described above, they meet every inbound train arriving at AT&T in the morning, and feed every outgoing train in the afternoon.

**Figure 20: Build Alternative 4 – Loop Shuttle Bus**

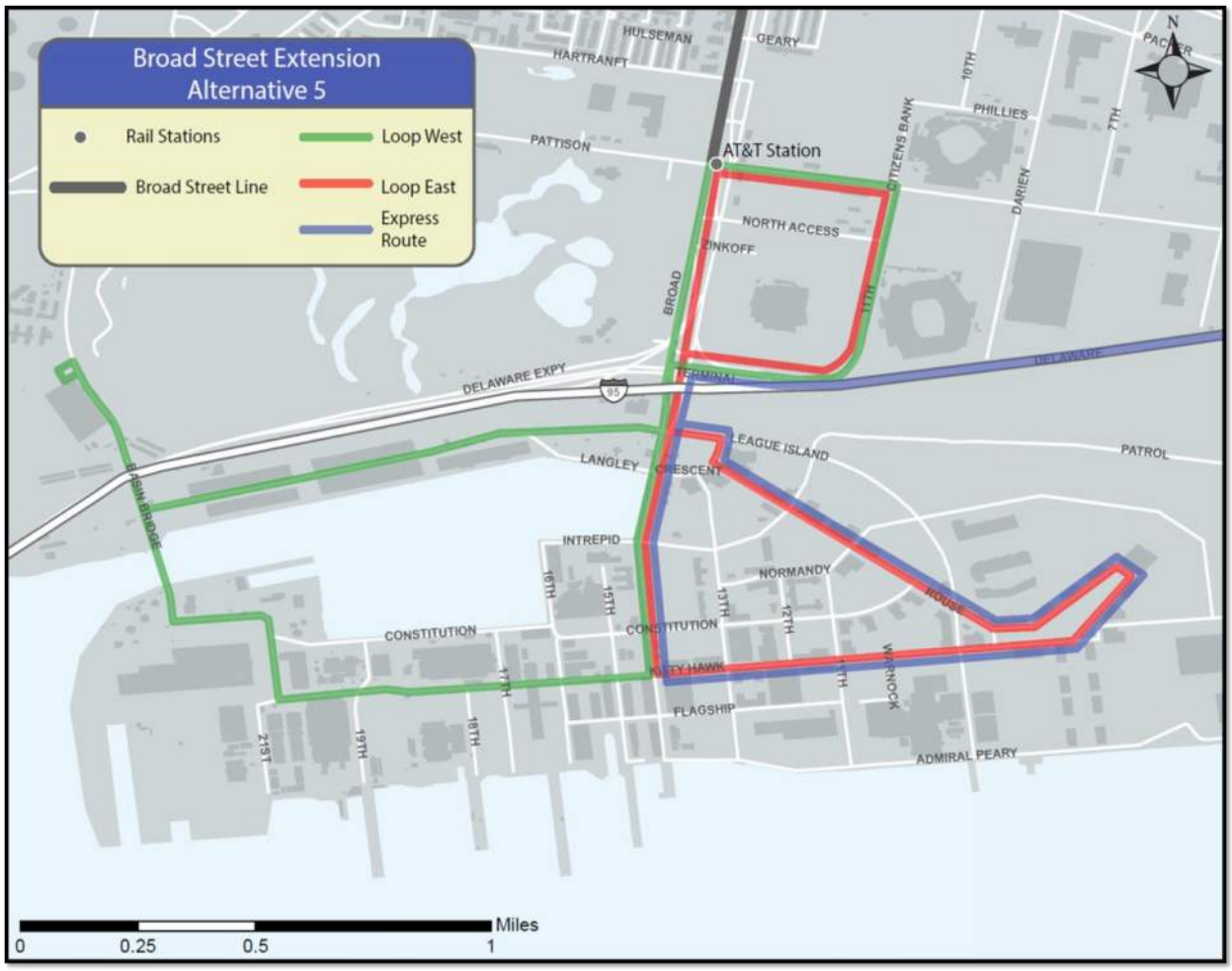



Source: HNTB, 2016

## 2040 Build Alternative 5

This alternative adds the Express shuttle bus to Build Alternative 4 as shown in **Figure 21**. Both the Loop and Express shuttle buses are free of charge.

**Figure 21: Build Alternative 5 – Loop and Express Shuttle Buses**

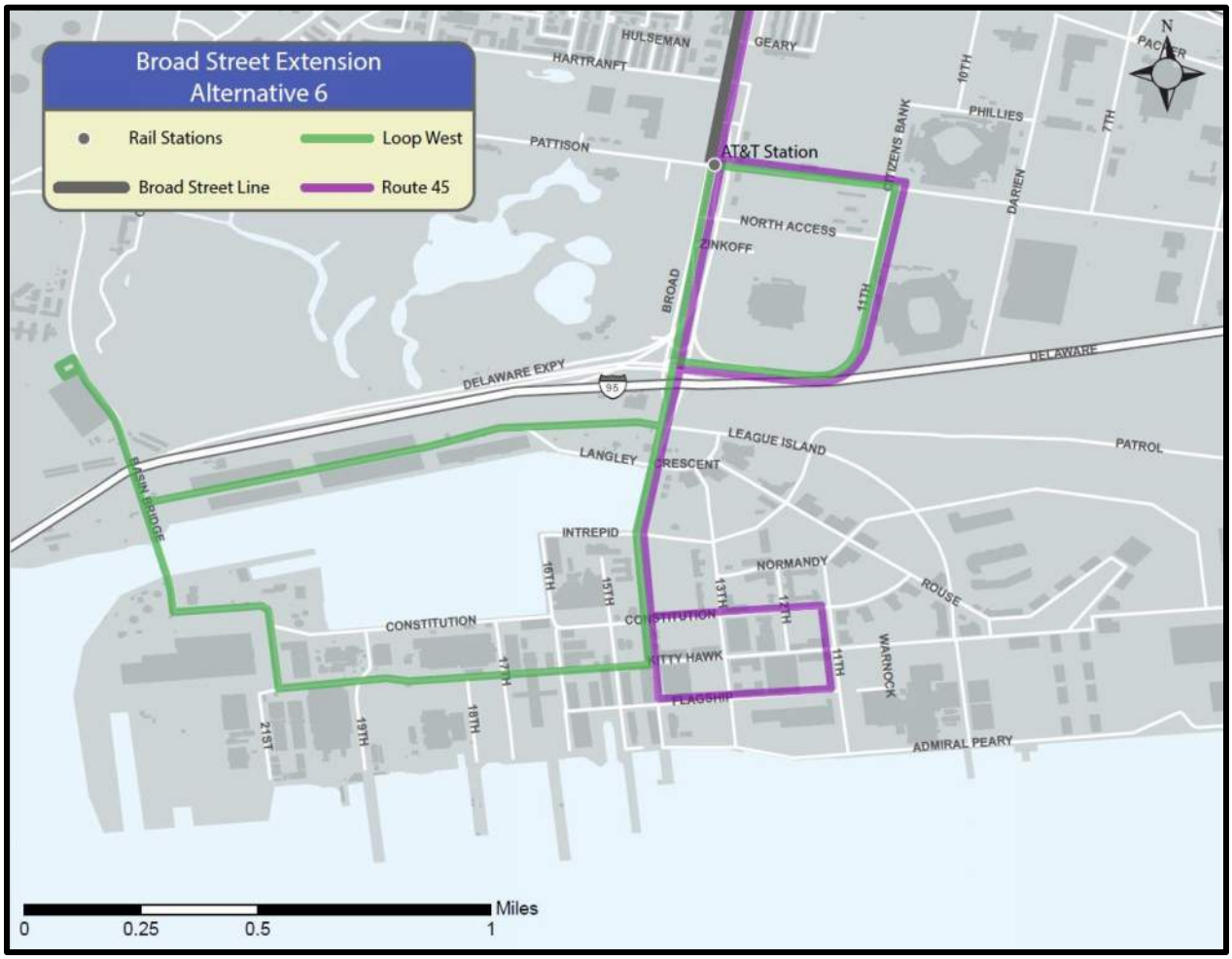



Source: HNTB, 2016

## 2040 Build Alternative 6

This alternative includes the West Loop shuttle bus shown above in Alternatives 4 and 5, and it extends SEPTA Route 45 from its current southern end point (Packer Avenue) into the Navy Yard as shown in **Figure 22**. Passengers pay the standard SEPTA bus fare to ride Route 45, but the Loop shuttle bus is free.

**Figure 22: Build Alternative 6 – Loop Shuttle Bus and SEPTA Route 45 Extension**




Source: HNTB, 2016

**Table 9: Assumed Number of Spaces and Cost of Parking**

| Station / TAZ | Parking Spaces in 2013 | Parking Spaces in 2040 | Cost per Day (Alts 1 – 6) |
|---|---|---|---|
| AT&T Station | 350 | 350 | $1.00 |
| | | | |
| Navy Yard | 10,000 | 14,000 | Free |
| | | | |
| TOTAL | 10,350 | 14,350 | |

Source: SEPTA, 2016
PIDC, 2016

# Future Year Forecasts

This section of the memo presents the results of the analysis of the Broad Street Subway Extension in 2040. **Table 10** shows the 2040 No Build and Build boardings and alightings per day. Alternative 2 achieves the highest total of all six build alternatives with 11,400 passenger trips to and from the Navy Yard per day. The other two rail alternatives (Alts 1 and 3) both have 10,900 passengers per day, but there is a significant difference in mode of access. In the case of Alternative 1, there is only one station and a higher number of passengers are beyond a short walk and need to use the shuttle bus to get to and from the rail station. Whereas with Alternative 3, the second rail station brings more people within walking distance.

All three bus alternatives have considerably lower ridership than the rail alternatives. Alternative 5, which includes both the Loop and Express bus shuttles, achieves the highest total (9200 daily passenger trips). Alternative 6 has the lowest ridership of all the analyzed alternatives. Compared to the shuttle buses, Route 45 is a slower and more expensive (passengers pay fare) option. And it also stops short of the future growth planned for the eastern part (Mustin Park) of the Navy Yard campus.

The following modifications could increase ridership, or improve the project's New Starts score:

- Although the Navy Yard will probably never be able to achieve the density of development that currently exists in Center City Philadelphia, there is probably room for more intensive clustering of future development around the proposed rail stations. This is especially true for the area around the second station (Kitty Hawk) in Alternatives 2 and 3. Bringing more people within a short walk (under 5 minutes) of the rail stations would probably result in higher ridership. It could also reduce, or eliminate the need for the shuttle feeder bus.

- Charging for parking would result in a shift from auto to transit. A $5 per day fee could potentially result in a 33% increase in rail ridership.

- The projected growth in the Navy Yard is anticipated to result in much higher levels of traffic congestion. In particular the stretch of Broad Street from the I-95 interchange to the main entrance to the Navy Yard could become a bottleneck during the morning and afternoon peaks. This additional congestion will slow the buses down. For example, in Alternative 5, all three of the shuttle bus routes (Express, West Loop, and East Loop) travel through this stretch of Broad Street. But there may be several relatively low cost roadway improvements that could keep the buses moving. For example, converting one of the two lanes on Broad Street, and League Island Boulevard to bus only lanes.

- FTA's New Starts criteria counts ridership from lower income transit dependent households twice as much as higher income passengers. Many of the current jobs in the Navy Yard are high skill / high pay professional jobs, such as the research and development positions at GlaxoSmithKline. But there are also some more traditional blue collar manufacturing jobs located there. For example, the jobs in the western part of the Navy Yard at the TastyKake Bakery and Aker Shipyard. It may be possible to modify the type of development that is planned to occur in the Navy Yard, to attract more low income riders.

**Table 10: 2040 Daily Transit Trips To / From Navy Yard**

| Transit Mode | | 2040 Build Alt 1 | | | Build Alt 2 | | | Build Alt 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | High | **Total** | Low | High | **Total** | Low | High | **Total** |
| RAIL | Walk Access | 3,700 | 3,200 | **6,900** | 4,600 | 3,900 | **8,500** | 4,400 | 3,800 | **8,100** |
| | Bus Access | 2,500 | 1,400 | **4,000** | 1,900 | 900 | **2,900** | 1,900 | 900 | **2,800** |
| | TOTAL | 6,200 | 4,600 | **10,900** | 6,500 | 4,900 | **11,400** | 6,300 | 4,700 | **10,900** |

| Transit Mode | | 2040 No Build | | | Build Alt 4 | | | Build Alt 5 | | | Build Alt 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low | High | **Total** | Low | High | **Total** | Low | High | **Total** | Low | High | **Total** |
| BUS | Loop Shuttle | 2,700 | 2,000 | **4,700** | 5,300 | 3,600 | **8,900** | 4,500 | 2,900 | **7,400** | 480 | 310 | **790** |
| | Express Shuttle | 900 | 700 | **1,600** | | | | 900 | 800 | **1,800** | | | |
| | Route 45 | | | | | | | | | | 4,320 | 2,790 | **7,110** |
| | TOTAL | 3,600 | 2,700 | **6,300** | 5,300 | 3,600 | **8,900** | 5,400 | 3,700 | **9,200** | 4,800 | 3,100 | **7,900** |

Source: Delaware Valley Regional Planning Commission, 2017

## Risks to the Forecast

The forecast presented in this report covers a 27 year planning horizon. Needless to say, a lot can happen between 2013 and 2040. The following list of caveats is intended to identify several reasons why actual ridership may deviate from forecast levels:

- First and foremost, the Broad Street Subway extension ridership forecasts are based on population and employment forecasts that may or may not come true. Unforeseen changes in the national and regional economies and other market forces can have a profound effect on future land use and travel patterns.

- The ridership forecast is also heavily dependent on the service plan, transit fares, amount of parking provided, and parking costs identified in this report. Some of these factors may change between now and project implementation.

- Ridership is dependent on several external factors. In particular, fluctuations in the price of gasoline could have a significant impact on future transit ridership.

- Growth of transportation network providers (Uber & Lyft) and impacts of autonomous vehicles could both have effects on overall shares between highway & transit modes.

# Appendix

**Broad Street Subway Line Extension Schedule**

**Shuttle Bus Schedules**

**References**

# References


Project Website: http://bslxnavyyard.com

City of Philadelphia Planning Commission. *Lower South District Plan*. Adopted March 20, 2012. http://phila2035.org/home-page/district/lower-south/

Philadelphia Industrial Development Corporation (PIDC). *2004 Philadelphia Navy Yard Master Plan*. January 2004. http://www.navyyard.org/resources/

Philadelphia Industrial Development Corporation (PIDC). *The Navy Yard Master Plan 2013 Update*. http://www.navyyard.org/about-the-campus/master-plan/

City of Philadelphia Planning Commission and PIDC. *Lower Schuylkill Master Plan*. May 2013. http://www.navyyard.org/resources/

Parsons Brinckerhoff. *Broad Street Line Extension Feasibility Study*. September 2008. http://bslxnavyyard.com/pdfs/Final_BSL%20feasibility%20study%202008.pdf

Parsons Brinckerhoff. *Navy Yard Transportation Access Improvement Study*. September 2014.

Parsons Brinckerhoff. *The Navy Yard Commuter Survey*. October 2014.

Michael Baker International. *Broad Street Extension Study - Environmental Screening and Fatal Flaws Analysis*. April 7, 2016

# Broad Street Subway Line Extension to the Navy Yard

## Process Memorandum

**Publication Number:** PM15062

**Date Published:** November 2017

**Geographic Area Covered:** South Philadelphia

**Key Words:**
Broad Street Subway Line, Navy Yard, South Philadelphia, Ridership Forecast, SEPTA, FTA New Starts

**Abstract:**
The current southern terminus of the Broad Street Subway line is AT&T station at Pattison Avenue. The Navy Yard, located one mile south of AT&T station, is projected to experience considerable growth between 2013 and 2040. Employment is projected to increase from 9,900 to close to 30,000 employees, and the residential population is anticipated to increase from 0 to slightly over 1,000 households. This study estimates the passenger ridership that would result from either extending the subway line or greatly increasing bus service to the Navy Yard. Scenarios analyzed included 2013 Base, 2040 No Build, and six 2040 Build alternatives.

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# APPENDIX F

BROAD STREET SUBWAY LINE EXTENSION TO THE NAVY YARD – NEW STARTS TEMPLATES

# NEW STARTS TRAVEL FORECASTS TEMPLATE

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 1 Rouse Blvd |
|---|---|

## Trips on the Project

| Line | Transit market | Trips made by: | Daily linked trips | | Annualization factor | Annual linked trips (daily trips * annualization factor) | | Brief description of the process used to develop travel forecasts (e.g., local model, FTA simplified national model, incremental data-driven method, direct demand model) |
|---|---|---|---|---|---|---|---|---|
| | | | Current Year (2015) | Horizon (20 Years) | | Current Year (2015) | Horizon (20 Years) | |
| 1a | Modeled trips: home-based work (HBW) | Non-transit dependents | 1,805 | 4,370 | 365 | 658,825 | 1,595,050 | Local model |
| 1b | | Transit dependents | 2,470 | 5,890 | | 901,550 | 2,149,850 | |
| 2a | Modeled trips: all other trip purposes | Non-transit dependents | 95 | 230 | 365 | 34,675 | 83,950 | Local model |
| 2b | | Transit dependents | 130 | 310 | | 47,450 | 113,150 | |
| 3a | Special market 1 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 3b | | Transit dependents | | | | 0 | 0 | |
| 4a | Special market 2 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 4b | | Transit dependents | | | | 0 | 0 | |
| 5a | Special market 3 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 5b | | Transit dependents | | | | 0 | 0 | |
| 6a | Special market 4 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 6b | | Transit dependents | | | | 0 | 0 | |
| 7a | Subtotal (lines 1 through 6) | Non-transit dependents | | | | 693,500 | 1,679,000 | |
| 7b | | Transit dependents | | | | 949,000 | 2,263,000 | |
| 8a | **Total annual linked trips with special markets (lines 7a through 7b)** | | | | | **1,642,500** | **3,942,000** | |
| 8b | **Total daily linked trips without special markets (lines 1a through 2b)** | | **4,500** | **10,800** | | | | |
| 9 | New transit trips | | 400 | 4,600 | | | | |

## Vehicle-Miles of Travel (VMT)

| Line | Mode / Technology | Daily VMT | | | | Annualization factor | Annual VMT (for automobile, calculation is daily VMT * annualization factor; for transit, source is service plans for each mode/technology) | | | | VMT change (Build minus No-build VMT) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Current Year (2015) | | Horizon (20 Years) | | | Current Year (2015) | | Horizon (20 Years) | | Current Year (2015) | Horizon (20 Years) |
| | | No-build | Build | No-build | Build | | No-build | Build | No-build | Build | | |
| 10 | Automobile | 211,341,483 | 211,318,781 | 251,200,041 | 251,173,058 | 365 | 77,139,641,295 | 77,131,355,178 | 91,688,015,038 | 91,678,166,177 | -8,286,117 | -9,848,861 |
| 11 | Diesel bus | | | | | | | | | | 0 | 0 |
| 12 | Hybrid bus | | | | | | | | | | 0 | 0 |
| 13 | CNG bus | | | | | | | | | | 0 | 0 |
| 14 | Electric bus | | | | | | | | | | 0 | 0 |
| 15 | Heavy rail [1] | | | | | | | | | | 0 | 0 |
| 16 | Light rail / streetcar [1] | | | | | | | | | | 0 | 0 |
| 17 | Commuter rail (new diesel locomotive or DMU) [1] | | | | | | | | | | 0 | 0 |
| 18 | Commuter rail (used diesel locomotive) [1] | | | | | | | | | | 0 | 0 |
| 19 | Commuter rail (electric or EMU) [1] | | | | | | | | | | 0 | 0 |

[1] For rail transit modes, report VMT in terms of total rail passenger car mileage, not train mileage. (As an illustration of the difference, the rail passenger car mileage for a commuter rail or heavy rail train with six passenger cars would be six times the train mileage.)

# NEW STARTS MOBILITY, COST-EFFECTIVENESS, AND CONGESTION RELIEF TEMPLATE

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 1 Rouse Blvd |
|---|---|

## Mobility Improvements

| Line | Item | Values | | Source/Calculation |
|---|---|---|---|---|
| | | Current Year (2015) | Horizon (20 Years) | |
| 1 | Annual linked trips on the project with double weight for trips by transit-dependent persons | 2,591,500 | 6,205,000 | Travel Forecasts Template, Line 7a + 2 * Line 7b |
| 2 | Value used in rating | 4,398,250 | | If a 10- or 20-year horizon is used: 50 percent * Line 1 current year value + 50 percent * Line 1 horizon year value<br>If no horizon year is used: Line 1 current year value |
| | | MEDIUM-LOW | | |

## Cost Effectiveness

| Line | Item | Values | | Source/Calculation |
|---|---|---|---|---|
| | | Current Year (2015) | Horizon (20 Years) | |
| 3 | Annualized project capital cost excluding enrichments (constant 2016 dollars) | $22,121,014 | $22,121,014 | Source: SCC Build Annualized worksheets |
| 4 | Annual project operating and maintenance costs (constant 2016 dollars) | $2,176,570 | $2,176,570 | Source: O & M cost models (attach documentation) |
| 5 | Annual linked trips on the project | 1,642,500 | 3,942,000 | Travel Forecasts Template, Line 8a |
| 6 | Annualized project capital and operating cost excluding enrichments (constant 2016 dollars) | $24,297,584 | $24,297,584 | Line 3 + Line 4 |
| 7 | Annualized cost per annual linked trip on the project | $14.79 | $6.16 | Line 6 / Line 5 |
| 8 | Value used in rating | $10.48 | | If a 10- or 20-year horizon is used: 50 percent * Line 7 current year value + 50 percent * Line 7 horizon year value<br>If no horizon year is used: Line 7 current year value |
| | | MEDIUM-LOW | | |

## Congestion Relief

| Line | Item | Values | | Source/Calculation |
|---|---|---|---|---|
| | | Current Year (2015) | Horizon (20 Years) | |
| 9 | New Weekday Linked Transit Trips | 400 | 4,600 | Travel Forecasts Template, Line 9 |
| 10 | Value used in rating | 2,500 | | If a 10- or 20-year horizon is used: 50 percent * Line 7 current year value + 50 percent * Line 7 horizon year value<br>If no horizon year is used: Line 7 current year value |
| | | MEDIUM | | |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 1 Rouse Blvd |
|---|---|

## Attainment Status

| Line | Item | Values | Source/Calculation |
|---|---|---|---|
| 1 | Regional air quality attainment status, carbon monoxide (CO) | Maintenance | Source: EPA Green Book |
| 2 | Regional air quality attainment status, nitrogen dioxide ($NO_2$) | Maintenance | |
| 3 | Regional air quality attainment status, ozone ($O_3$) (2008 8-hour standard) | Nonattainment | |
| 4 | Regional air quality attainment status, particulate matter ($PM_{2.5}$) (2006 standard) | Maintenance | |

## ADDITIONAL ENVIRONMENTAL BENEFITS INPUTS REQUIRED FOR WARRANTED NEW STARTS PROJECTS ONLY

| Line | | Values | Source/Calculation |
|---|---|---|---|
| A | Existing Annual Transit Ridership in the Corridor Today | | Input by project sponsor |
| B | Percentage Change in Corridor Annual Transit Vehicle Hours That Would Result from Implementation of the Proposed Project | | Input by project sponsor |
| C | Elasticity Factor | | TCRP Report 95, Traveler Response to Transportation System Changes: Transit Scheduling and Frequency (2004) |
| D | Estimated Increase in Annual Project Ridership | | Line A * Line B * Line C |
| E | Average share of transit users that previously drove | | Factor based on data from past projects in the CIG program |
| F | Estimated new transit ridership coming from autos | | Line D * Line E |
| G | Average auto occupany factor | | Nation-wide average for work trips from the 2009 National Household Travel Survey |
| H | Estimated decrease (increase) in auto trips | | Line F / Line G |
| I | Project Length | | From Project Description Template |
| J | Average trip length factor | | Factor based on data from past projects in the CIG program |
| K | Estimated decrease (increase) in Annual Auto Vehicle Miles Travelled | | Line H * Line I * Line J |

## Summary Results

| | | Current Year (2015) | Horizon (20 Years) | |
|---|---|---|---|---|
| 5 | Value of environmental benefits | $2,276,275 | $2,522,610 | Sum of lines 19, 30, 41, 52, 63, 74, 85 and 96 for current and applicable (if any) horizon year |
| 6 | Annualized capital and operating cost of project | $24,297,584 | $24,297,584 | Mobility and Cost Effectiveness Template, Line 6 |
| 7 | Ratio of environmental benefits to annualized cost | 9.4% | 10.4% | Line 5 / Line 6 |
| 8 | Value used in rating | 9.9% | | If a 10- or 20-year horizon is being used: 50 percent * Line 7 current year value + 50 percent * Line 7 horizon year value<br>If no horizon year is being used: Line 7 current year value |
| | | MEDIUM-HIGH | | |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 2)

## VALUE OF BENEFITS BY FACTOR

### Air Quality: Carbon Monoxide (CO)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 9 | Automobile | 8,286,117 | 0.01677 | 138,958.18 | $0.10 | **$13,895.82** | --- | 0.01146 | --- | $0.10 | --- | 9,848,861 | 0.01026 | 101,049.31 | $0.10 | **$10,104.93** |
| 10 | Diesel Bus | 0 | 0.00583 | 0.00 | $0.10 | **$0.00** | --- | 0.00326 | --- | $0.10 | --- | 0 | 0.00289 | 0.00 | $0.10 | **$0.00** |
| 11 | Hybrid Bus | 0 | 0.00583 | 0.00 | $0.10 | **$0.00** | --- | 0.00326 | --- | $0.10 | --- | 0 | 0.00289 | 0.00 | $0.10 | **$0.00** |
| 12 | CNG Bus | 0 | 0.03962 | 0.00 | $0.10 | **$0.00** | --- | 0.02030 | --- | $0.10 | --- | 0 | 0.01716 | 0.00 | $0.10 | **$0.00** |
| 13 | Electric Bus | 0 | 0.00645 | 0.00 | $0.10 | **$0.00** | --- | 0.00539 | --- | $0.10 | --- | 0 | 0.00504 | 0.00 | $0.10 | **$0.00** |
| 14 | Heavy Rail | 0 | 0.00706 | 0.00 | $0.10 | **$0.00** | --- | 0.00685 | --- | $0.10 | --- | 0 | 0.00673 | 0.00 | $0.10 | **$0.00** |
| 15 | Light Rail / Streetcar | 0 | 0.01051 | 0.00 | $0.10 | **$0.00** | --- | 0.01020 | --- | $0.10 | --- | 0 | 0.01001 | 0.00 | $0.10 | **$0.00** |
| 16 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** | --- | 0.01680 | --- | $0.10 | --- | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** |
| 17 | Commuter Rail - Used diesel locomotive | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** | --- | 0.01680 | --- | $0.10 | --- | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** |
| 18 | Commuter Rail - Electric or EMU | 0 | 0.01281 | 0.00 | $0.10 | **$0.00** | --- | 0.01243 | --- | $0.10 | --- | 0 | 0.01219 | 0.00 | $0.10 | **$0.00** |
| 19 | TOTAL CHANGE | **8,286,117** | --- | **138,958.18** | --- | **$13,895.82** | --- | --- | --- | --- | --- | **9,848,861** | --- | **101,049.31** | --- | **$10,104.93** |

### Air Quality: Mono-Nitrogen Oxides ($NO_x$)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 20 | Automobile | 8,286,117 | 0.00091 | 7,540.37 | $16.20 | **$122,153.93** | --- | 0.00028 | --- | $19.58 | --- | 9,848,861 | 0.00020 | 1,969.77 | $20.25 | **$39,887.89** |
| 21 | Diesel Bus | 0 | 0.00867 | 0.00 | $16.20 | **$0.00** | --- | 0.00208 | --- | $19.58 | --- | 0 | 0.00114 | 0.00 | $20.25 | **$0.00** |
| 22 | Hybrid Bus | 0 | 0.00867 | 0.00 | $16.20 | **$0.00** | --- | 0.00208 | --- | $19.58 | --- | 0 | 0.00114 | 0.00 | $20.25 | **$0.00** |
| 23 | CNG Bus | 0 | 0.00384 | 0.00 | $16.20 | **$0.00** | --- | 0.00341 | --- | $19.58 | --- | 0 | 0.00335 | 0.00 | $20.25 | **$0.00** |
| 24 | Electric Bus | 0 | 0.00583 | 0.00 | $22.95 | **$0.00** | --- | 0.00439 | --- | $28.69 | --- | 0 | 0.00398 | 0.00 | $29.70 | **$0.00** |
| 25 | Heavy Rail | 0 | 0.00638 | 0.00 | $22.95 | **$0.00** | --- | 0.00558 | --- | $28.69 | --- | 0 | 0.00532 | 0.00 | $29.70 | **$0.00** |
| 26 | Light Rail / Streetcar | 0 | 0.00950 | 0.00 | $22.95 | **$0.00** | --- | 0.00831 | --- | $28.69 | --- | 0 | 0.00791 | 0.00 | $29.70 | **$0.00** |
| 27 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.01320 | 0.00 | $16.20 | **$0.00** | --- | 0.01320 | --- | $19.58 | --- | 0 | 0.01320 | 0.00 | $20.25 | **$0.00** |
| 28 | Commuter Rail - Used diesel locomotive | 0 | 0.09300 | 0.00 | $16.20 | **$0.00** | --- | 0.04300 | --- | $19.58 | --- | 0 | 0.02090 | 0.00 | $20.25 | **$0.00** |
| 29 | Commuter Rail - Electric or EMU | 0 | 0.01157 | 0.00 | $22.95 | **$0.00** | --- | 0.01012 | --- | $28.69 | --- | 0 | 0.00964 | 0.00 | $29.70 | **$0.00** |
| 30 | TOTAL CHANGE | **8,286,117** | --- | **7,540.37** | --- | **$122,153.93** | --- | --- | --- | --- | --- | **9,848,861** | --- | **1,969.77** | --- | **$39,887.89** |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 3)

## Air Quality: Volatile Organic Compounds (VOCs)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 31 | Automobile | 8,286,117 | 0.00060 | 4,971.67 | $4.53 | **$22,521.66** | --- | 0.00027 | --- | $5.63 | --- | 9,848,861 | 0.00021 | 2,068.26 | $5.84 | **$12,078.64** |
| 32 | Diesel Bus | 0 | 0.00073 | 0.00 | $4.53 | **$0.00** | --- | 0.00024 | --- | $5.63 | --- | 0 | 0.00016 | 0.00 | $5.84 | **$0.00** |
| 33 | Hybrid Bus | 0 | 0.00073 | 0.00 | $4.53 | **$0.00** | --- | 0.00024 | --- | $5.63 | --- | 0 | 0.00016 | 0.00 | $5.84 | **$0.00** |
| 34 | CNG Bus | 0 | 0.00146 | 0.00 | $4.53 | **$0.00** | --- | 0.00115 | --- | $5.63 | --- | 0 | 0.00111 | 0.00 | $5.84 | **$0.00** |
| 35 | Electric Bus | 0 | 0.00012 | 0.00 | $4.53 | **$0.00** | --- | 0.00010 | --- | $5.63 | --- | 0 | 0.00010 | 0.00 | $5.84 | **$0.00** |
| 36 | Heavy Rail | 0 | 0.00013 | 0.00 | $4.53 | **$0.00** | --- | 0.00013 | --- | $5.63 | --- | 0 | 0.00013 | 0.00 | $5.84 | **$0.00** |
| 37 | Light Rail / Streetcar | 0 | 0.00019 | 0.00 | $4.53 | **$0.00** | --- | 0.00019 | --- | $5.63 | --- | 0 | 0.00020 | 0.00 | $5.84 | **$0.00** |
| 38 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.00055 | 0.00 | $4.53 | **$0.00** | --- | 0.00055 | --- | $5.63 | --- | 0 | 0.00055 | 0.00 | $5.84 | **$0.00** |
| 39 | Commuter Rail - Used diesel locomotive | 0 | 0.00436 | 0.00 | $4.53 | **$0.00** | --- | 0.00126 | --- | $5.63 | --- | 0 | 0.00044 | 0.00 | $5.84 | **$0.00** |
| 40 | Commuter Rail - Electric or EMU | 0 | 0.00024 | 0.00 | $4.53 | **$0.00** | --- | 0.00023 | --- | $5.63 | --- | 0 | 0.00024 | 0.00 | $5.84 | **$0.00** |
| 41 | TOTAL CHANGE | **8,286,117** | --- | **4,971.67** | --- | **$22,521.66** | --- | --- | --- | --- | --- | **9,848,861** | --- | **2,068.26** | --- | **$12,078.64** |

## Air Quality: Particulate Matter ($PM_{2.5}$)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 42 | Automobile | 8,286,117 | 0.000010 | 82.86 | $850.50 | **$70,473.42** | --- | 0.000010 | --- | $1,076.63 | --- | 9,848,861 | 0.000010 | 98.49 | $1,120.50 | **$110,356.48** |
| 43 | Diesel Bus | 0 | 0.000480 | 0.00 | $850.50 | **$0.00** | --- | 0.000090 | --- | $1,076.63 | --- | 0 | 0.000030 | 0.00 | $1,120.50 | **$0.00** |
| 44 | Hybrid Bus | 0 | 0.000480 | 0.00 | $850.50 | **$0.00** | --- | 0.000090 | --- | $1,076.63 | --- | 0 | 0.000030 | 0.00 | $1,120.50 | **$0.00** |
| 45 | CNG Bus | 0 | 0.000010 | 0.00 | $850.50 | **$0.00** | --- | 0.000010 | --- | $1,076.63 | --- | 0 | 0.000010 | 0.00 | $1,120.50 | **$0.00** |
| 46 | Electric Bus | 0 | 0.000378 | 0.00 | $702.00 | **$0.00** | --- | 0.000313 | --- | $860.63 | --- | 0 | 0.000299 | 0.00 | $891.00 | **$0.00** |
| 47 | Heavy Rail | 0 | 0.000413 | 0.00 | $702.00 | **$0.00** | --- | 0.000398 | --- | $860.63 | --- | 0 | 0.000399 | 0.00 | $891.00 | **$0.00** |
| 48 | Light Rail / Streetcar | 0 | 0.000615 | 0.00 | $702.00 | **$0.00** | --- | 0.000593 | --- | $860.63 | --- | 0 | 0.000593 | 0.00 | $891.00 | **$0.00** |
| 49 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.000190 | 0.00 | $850.50 | **$0.00** | --- | 0.000190 | --- | $1,076.63 | --- | 0 | 0.000190 | 0.00 | $1,120.50 | **$0.00** |
| 50 | Commuter Rail - Used diesel locomotive | 0 | 0.004600 | 0.00 | $850.50 | **$0.00** | --- | 0.001330 | --- | $1,076.63 | --- | 0 | 0.000470 | 0.00 | $1,120.50 | **$0.00** |
| 51 | Commuter Rail - Electric or EMU | 0 | 0.000750 | 0.00 | $702.00 | **$0.00** | --- | 0.000722 | --- | $860.63 | --- | 0 | 0.000723 | 0.00 | $891.00 | **$0.00** |
| 52 | TOTAL CHANGE | **8,286,117** | --- | **82.86** | --- | **$70,473.42** | --- | --- | --- | --- | --- | **9,848,861** | --- | **98.49** | --- | **$110,356.48** |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 4)

## Greenhouse Gases (Carbon Dioxide Equivalent [$CO_2e$])

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (ton) / VMT | Emissions Decrease (Increase) (tons) | Monetization Factor ($ / ton) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (ton) / VMT | Emissions Decrease (Increase) (tons) | Monetization Factor ($ / ton) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (ton) / VMT | Emissions Decrease (Increase) (tons) | Monetization Factor ($ / ton) | Value of Improvement [1] |
| 53 | Automobile | 8,286,117 | 0.000532 | 4,408.21 | $38.00 | **$167,512.13** | --- | 0.000434 | --- | $38.00 | --- | 9,848,861 | 0.000397 | 3,910.00 | $38.00 | **$148,579.91** |
| 54 | Diesel Bus | 0 | 0.003319 | 0.00 | $38.00 | **$0.00** | --- | 0.002854 | --- | $38.00 | --- | 0 | 0.002721 | 0.00 | $38.00 | **$0.00** |
| 55 | Hybrid Bus | 0 | 0.002655 | 0.00 | $38.00 | **$0.00** | --- | 0.002283 | --- | $38.00 | --- | 0 | 0.002177 | 0.00 | $38.00 | **$0.00** |
| 56 | CNG Bus | 0 | 0.002935 | 0.00 | $38.00 | **$0.00** | --- | 0.002524 | --- | $38.00 | --- | 0 | 0.002406 | 0.00 | $38.00 | **$0.00** |
| 57 | Electric Bus | 0 | 0.002934 | 0.00 | $38.00 | **$0.00** | --- | 0.002441 | --- | $38.00 | --- | 0 | 0.002303 | 0.00 | $38.00 | **$0.00** |
| 58 | Heavy Rail | 0 | 0.003211 | 0.00 | $38.00 | **$0.00** | --- | 0.003106 | --- | $38.00 | --- | 0 | 0.003073 | 0.00 | $38.00 | **$0.00** |
| 59 | Light Rail / Streetcar | 0 | 0.004779 | 0.00 | $38.00 | **$0.00** | --- | 0.004623 | --- | $38.00 | --- | 0 | 0.004574 | 0.00 | $38.00 | **$0.00** |
| 60 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** | --- | 0.007970 | --- | $38.00 | --- | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** |
| 61 | Commuter Rail - Used diesel locomotive | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** | --- | 0.007970 | --- | $38.00 | --- | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** |
| 62 | Commuter Rail - Electric or EMU | 0 | 0.005821 | 0.00 | $38.00 | **$0.00** | --- | 0.005632 | --- | $38.00 | --- | 0 | 0.005572 | 0.00 | $38.00 | **$0.00** |
| 63 | TOTAL CHANGE | **8,286,117** | --- | **4,408.21** | --- | **$167,512.13** | --- | --- | --- | --- | --- | **9,848,861** | --- | **3,910.00** | --- | **$148,579.91** |

## Energy Use (British Thermal Units [Btu])

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Energy Use (million Btu) / VMT | Energy Use Decrease (Increase) (million Btu) | Monetization Factor ($ / million Btu) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Energy Use (million Btu) / VMT | Energy Use Decrease (Increase) (million Btu) | Monetization Factor ($ / million Btu) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Energy Use (million Btu) / VMT | Energy Use Decrease (Increase) (million Btu) | Monetization Factor ($ / million Btu) | Value of Improvement [1] |
| 64 | Automobile | 8,286,117 | 0.007559 | 62,634.76 | $1.72 | **$107,731.78** | --- | 0.006167 | --- | $1.72 | --- | 9,848,861 | 0.005633 | 55,478.63 | $1.72 | **$95,423.25** |
| 65 | Diesel Bus | 0 | 0.041436 | 0.00 | $1.56 | **$0.00** | --- | 0.035635 | --- | $1.56 | --- | 0 | 0.033978 | 0.00 | $1.56 | **$0.00** |
| 66 | Hybrid Bus | 0 | 0.033149 | 0.00 | $1.56 | **$0.00** | --- | 0.028508 | --- | $1.56 | --- | 0 | 0.027182 | 0.00 | $1.56 | **$0.00** |
| 67 | CNG Bus | | | | | | | | | | | | | | | |
| 68 | Electric Bus | | | | | | | | | | | | | | | |
| 69 | Heavy Rail | | | | | | | | | | | | | | | |
| 70 | Light Rail / Streetcar | | | | | | | | | | | | | | | |
| 71 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** | --- | 0.096138 | --- | $1.56 | --- | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** |
| 72 | Commuter Rail - Used diesel locomotive | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** | --- | 0.096138 | --- | $1.56 | --- | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** |
| 73 | Commuter Rail - Electric or EMU | | | | | | | | | | | | | | | |
| 74 | TOTAL CHANGE | **8,286,117** | --- | **62,634.76** | --- | **$107,731.78** | --- | --- | --- | --- | --- | **9,848,861** | --- | **55,478.63** | --- | **$95,423.25** |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 5)

## Safety: Fatalities

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Fatalities / VMT | Fatality Decrease (Increase) | Monetization Factor ($ / fatality) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Fatalities / VMT | Fatality Decrease (Increase) | Monetization Factor ($ / fatality) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Fatalities / VMT | Fatality Decrease (Increase) | Monetization Factor ($ / fatality) | Value of Improvement [1] |
| 75 | Automobile | 8,286,117 | 0.000000013 | 0.11 | $9,100,000 | **$980,247.59** | --- | 0.000000013 | --- | $9,100,000 | --- | 9,848,861 | 0.000000013 | 0.13 | $9,100,000 | **$1,165,120.22** |
| 76 | Diesel Bus | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | --- | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 77 | Hybrid Bus | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | --- | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 78 | CNG Bus | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | --- | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 79 | Electric Bus | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | --- | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 80 | Heavy Rail | 0 | 0.000000007 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000007 | --- | $9,100,000 | --- | 0 | 0.000000007 | 0.00 | $9,100,000 | **$0.00** |
| 81 | Light Rail / Streetcar | 0 | 0.000000009 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000009 | --- | $9,100,000 | --- | 0 | 0.000000009 | 0.00 | $9,100,000 | **$0.00** |
| 82 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000012 | --- | $9,100,000 | --- | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** |
| 83 | Commuter Rail - Used diesel locomotive | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000012 | --- | $9,100,000 | --- | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** |
| 84 | Commuter Rail - Electric or EMU | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000012 | --- | $9,100,000 | --- | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** |
| **85** | **TOTAL CHANGE** | **8,286,117** | **---** | **0.11** | **---** | **$980,247.59** | **---** | **---** | **---** | **---** | **---** | **9,848,861** | **---** | **0.13** | **---** | **$1,165,120.22** |

## Safety: Injuries

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Injuries / VMT | Injury Decrease (Increase) | Monetization Factor ($ / injury) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Injuries / VMT | Injury Decrease (Increase) | Monetization Factor ($ / injury) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Injuries / VMT | Injury Decrease (Increase) | Monetization Factor ($ / injury) | Value of Improvement [1] |
| 86 | Automobile | 8,286,117 | 0.000000195 | 1.62 | $490,000 | **$791,738.44** | --- | 0.000000195 | --- | $490,000 | --- | 9,848,861 | 0.000000195 | 1.92 | $490,000 | **$941,058.64** |
| 87 | Diesel Bus | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** | --- | 0.000001824 | --- | $490,000 | --- | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** |
| 88 | Hybrid Bus | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** | --- | 0.000001824 | --- | $490,000 | --- | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** |
| 89 | CNG Bus | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** | --- | 0.000001824 | --- | $490,000 | --- | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** |
| 90 | Electric Bus | 0 | 0.000001458 | 0.00 | $490,000 | **$0.00** | --- | 0.000001458 | --- | $490,000 | --- | 0 | 0.000001458 | 0.00 | $490,000 | **$0.00** |
| 91 | Heavy Rail | 0 | 0.000000155 | 0.00 | $490,000 | **$0.00** | --- | 0.000000155 | --- | $490,000 | --- | 0 | 0.000000155 | 0.00 | $490,000 | **$0.00** |
| 92 | Light Rail / Streetcar | 0 | 0.000001696 | 0.00 | $490,000 | **$0.00** | --- | 0.000001696 | --- | $490,000 | --- | 0 | 0.000001696 | 0.00 | $490,000 | **$0.00** |
| 93 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** | --- | 0.000001746 | --- | $490,000 | --- | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** |
| 94 | Commuter Rail - Used diesel locomotive | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** | --- | 0.000001746 | --- | $490,000 | --- | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** |
| 95 | Commuter Rail - Electric or EMU | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** | --- | 0.000001746 | --- | $490,000 | --- | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** |
| **96** | **TOTAL CHANGE** | **8,286,117** | **---** | **1.62** | **---** | **$791,738.44** | **---** | **---** | **---** | **---** | **---** | **9,848,861** | **---** | **1.92** | **---** | **$941,058.64** |

[1] Value will be positive for decreases and negative for increases.

# NEW STARTS RATING ESTIMATION

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 1 Rouse Blvd |
|---|---|

Use this tool to calculate your New Starts project's potential overall rating. Enter a value from the drop down menu in each of the yellow cells based on the ratings you anticipate. *

**Project Justification**

| Criterion | Weight | Estimated Rating | Source/Calculation |
|---|---|---|---|
| Mobility Improvements | 16.66% | MEDIUM-LOW | Mobility, Cost-Effectiveness, and Congestion Relief Templates |
| Cost Effectiveness | 16.66% | MEDIUM-LOW | |
| Congestion Relief | 16.66% | MEDIUM | |
| Environmental Benefits | 16.66% | MEDIUM-HIGH | Environmental Benefits Template |
| Land Use | 16.66% | LOW | Enter your estimations of these ratings. See FTA's Guidelines for Land Use and Economic Development Effects on how FTA determines the ratings for these criteria. |
| Economic Development | 16.66% | MEDIUM | |
| Summary Rating | | MEDIUM | Ratings are assigned to each criterion on a five-point scale, with Low = 1, Medium-Low =2, Medium = 3, Medium-High = 4, and High = 5. Individual criterion ratings are then weighted 16.66% each to develop the summary Project Justification rating. |

**Local Financial Commitment**

| Criterion | Weight | Estimated Rating | Source/Calculation |
|---|---|---|---|
| Current Financial Condition | 25% | MEDIUM | Enter your estimations of these ratings. See the Local Financial Commitment section in the New Starts chapter of the CIG Program Final Interim Policy Guidance for information on how FTA rates these factors. |
| Commitment of Capital and Operating Funds | 25% | MEDIUM | |
| Reasonableness of Financial Plan | 50% | MEDIUM | |
| New Starts Share (Please complete the Finance Template) | - | - | Finance Template |
| Summary Rating | | MEDIUM | Ratings are assigned to each subfactor on a five-point scale, with Low = 1, Medium-Low = 2, Medium = 3, Medium-High = 4, and High = 5. Individual subfactor ratings are then weighted as shown to develop the summary Local Financial Commitment rating. If the summary rating is at least Medium and the New Starts share is less than 50%, the summary rating is increased one level. |

| Estimated Overall Project Rating: (The Project Justification and Local Financial Commitment summary ratings are each weighted equally at 50%. However, both must be at least Medium to obtain a Medium or better overall rating.) | MEDIUM |
|---|---|

Link to CIG Program Guidance on the FTA Website

* FTA is providing this tool to help project sponsors understand how their projects might rate. Any anticipated ratings entered into this spreadsheet will not be used by FTA to inform the ratings that FTA assigns. All ratings automatically computed in the templates are subject to verification by FTA. FTA has sole responsibility for assigning project ratings according to the evaluation and rating framework described in the Capital Investment Grant Program Final Interim Policy Guidance.

# NEW STARTS TRAVEL FORECASTS TEMPLATE

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 2 - 13th St & Constitution Ave |
|---|---|

## Trips on the Project

| Line | Transit market | Trips made by: | Daily linked trips | | Annualization factor | Annual linked trips (daily trips * annualization factor) | | Brief description of the process used to develop travel forecasts (e.g., local model, FTA simplified national model, incremental data-driven method, direct demand model) |
|---|---|---|---|---|---|---|---|---|
| | | | Current Year (2015) | Horizon (20 Years) | | Current Year (2015) | Horizon (20 Years) | |
| 1a | Modeled trips: home-based work (HBW) | Non-transit dependents | 4,165 | 4,655 | 365 | 1,520,152 | 1,699,075 | Local model |
| 1b | | Transit dependents | 5,525 | 6,175 | | 2,016,698 | 2,253,875 | |
| 2a | Modeled trips: all other trip purposes | Non-transit dependents | 219 | 245 | 365 | 80,008 | 89,425 | Local model |
| 2b | | Transit dependents | 291 | 325 | | 106,142 | 118,625 | |
| 3a | Special market 1 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 3b | | Transit dependents | | | | 0 | 0 | |
| 4a | Special market 2 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 4b | | Transit dependents | | | | 0 | 0 | |
| 5a | Special market 3 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 5b | | Transit dependents | | | | 0 | 0 | |
| 6a | Special market 4 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 6b | | Transit dependents | | | | 0 | 0 | |
| 7a | Subtotal (lines 1 through 6) | Non-transit dependents | | | | 1,600,160 | 1,788,500 | |
| 7b | | Transit dependents | | | | 2,122,840 | 2,372,500 | |
| 8a | **Total annual linked trips with special markets (lines 7a through 7b)** | | | | | **3,723,000** | **4,161,000** | |
| 8b | **Total daily linked trips without special markets (lines 1a through 2b)** | | **10,200** | **11,400** | | | | |
| 9 | New transit trips | | 0 | 5,100 | | | | |

## Vehicle-Miles of Travel (VMT)

| Line | Mode / Technology | Daily VMT | | | | Annualization factor | Annual VMT (for automobile, calculation is daily VMT * annualization factor; for transit, source is service plans for each mode/technology) | | | | VMT change (Build minus No-build VMT) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Current Year (2015) | | Horizon (20 Years) | | | Current Year (2015) | | Horizon (20 Years) | | Current Year (2015) | Horizon (20 Years) |
| | | No-build | Build | No-build | Build | | No-build | Build | No-build | Build | | |
| 10 | Automobile | 95,456,016 | 95,426,966 | 251,200,041 | 251,123,594 | 365 | 34,841,445,714 | 34,830,842,438 | 91,688,015,038 | 91,660,111,679 | -10,603,277 | -27,903,359 |
| 11 | Diesel bus | | | | | | | | | | 0 | 0 |
| 12 | Hybrid bus | | | | | | | | | | 0 | 0 |
| 13 | CNG bus | | | | | | | | | | 0 | 0 |
| 14 | Electric bus | | | | | | | | | | 0 | 0 |
| 15 | Heavy rail [1] | | | | | | | | | | 0 | 0 |
| 16 | Light rail / streetcar [1] | | | | | | | | | | 0 | 0 |
| 17 | Commuter rail (new diesel locomotive or DMU) [1] | | | | | | | | | | 0 | 0 |
| 18 | Commuter rail (used diesel locomotive) [1] | | | | | | | | | | 0 | 0 |
| 19 | Commuter rail (electric or EMU) [1] | | | | | | | | | | 0 | 0 |

[1] For rail transit modes, report VMT in terms of total rail passenger car mileage, not train mileage. (As an illustration of the difference, the rail passenger car mileage for a commuter rail or heavy rail train with six passenger cars would be six times the train mileage.)

# NEW STARTS MOBILITY, COST-EFFECTIVENESS, AND CONGESTION RELIEF TEMPLATE

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 2 - 13th St & Constitution Ave |
|---|---|

## Mobility Improvements

| Line | Item | Values | | Source/Calculation |
|---|---|---|---|---|
| | | Current Year (2015) | Horizon (20 Years) | |
| 1 | Annual linked trips on the project with double weight for trips by transit-dependent persons | 5,845,840 | 6,533,500 | Travel Forecasts Template, Line 7a + 2 * Line 7b |
| 2 | Value used in rating | 6,189,670 | | If a 10- or 20-year horizon is used: 50 percent * Line 1 current year value + 50 percent * Line 1 horizon year value<br>If no horizon year is used: Line 1 current year value |
| | | MEDIUM | | |

## Cost Effectiveness

| Line | Item | Values | | Source/Calculation |
|---|---|---|---|---|
| | | Current Year (2015) | Horizon (20 Years) | |
| 3 | Annualized project capital cost excluding enrichments (constant 2016 dollars) | $40,192,260 | $40,192,260 | Source: SCC Build Annualized worksheets |
| 4 | Annual project operating and maintenance costs (constant 2016 dollars) | $3,431,898 | $3,431,898 | Source: O & M cost models (attach documentation) |
| 5 | Annual linked trips on the project | 3,723,000 | 4,161,000 | Travel Forecasts Template, Line 8a |
| 6 | Annualized project capital and operating cost excluding enrichments (constant 2016 dollars) | $43,624,158 | $43,624,158 | Line 3 + Line 4 |
| 7 | Annualized cost per annual linked trip on the project | $11.72 | $10.48 | Line 6 / Line 5 |
| 8 | Value used in rating | $11.10 | | If a 10- or 20-year horizon is used: 50 percent * Line 7 current year value + 50 percent * Line 7 horizon year value<br>If no horizon year is used: Line 7 current year value |
| | | MEDIUM-LOW | | |

## Congestion Relief

| Line | Item | Values | | Source/Calculation |
|---|---|---|---|---|
| | | Current Year (2015) | Horizon (20 Years) | |
| 9 | New Weekday Linked Transit Trips | 0 | 5,100 | Travel Forecasts Template, Line 9 |
| 10 | Value used in rating | 2,550 | | If a 10- or 20-year horizon is used: 50 percent * Line 7 current year value + 50 percent * Line 7 horizon year value<br>If no horizon year is used: Line 7 current year value |
| | | MEDIUM | | |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 2 - 13th St & Constitution Ave |
|---|---|

## Attainment Status

| Line | Item | Values | Source/Calculation |
|---|---|---|---|
| 1 | Regional air quality attainment status, carbon monoxide (CO) | Maintenance | Source: EPA Green Book |
| 2 | Regional air quality attainment status, nitrogen dioxide ($NO_2$) | Maintenance | |
| 3 | Regional air quality attainment status, ozone ($O_3$) (2008 8-hour standard) | Nonattainment | |
| 4 | Regional air quality attainment status, particulate matter ($PM_{2.5}$) (2006 standard) | Maintenance | |

## ADDITIONAL ENVIRONMENTAL BENEFITS INPUTS REQUIRED FOR WARRANTED NEW STARTS PROJECTS ONLY

| Line | | Values | Source/Calculation |
|---|---|---|---|
| A | Existing Annual Transit Ridership in the Corridor Today | [redacted] | Input by project sponsor |
| B | Percentage Change in Corridor Annual Transit Vehicle Hours That Would Result from Implementation of the Proposed Project | | Input by project sponsor |
| C | Elasticity Factor | | TCRP Report 95, Traveler Response to Transportation System Changes: Transit Scheduling and Frequency (2004) |
| D | Estimated Increase in Annual Project Ridership | | Line A * Line B * Line C |
| E | Average share of transit users that previously drove | | Factor based on data from past projects in the CIG program |
| F | Estimated new transit ridership coming from autos | | Line D * Line E |
| G | Average auto occupany factor | | Nation-wide average for work trips from the 2009 National Household Travel Survey |
| H | Estimated decrease (increase) in auto trips | | Line F / Line G |
| I | Project Length | | From Project Description Template |
| J | Average trip length factor | | Factor based on data from past projects in the CIG program |
| K | Estimated decrease (increase) in Annual Auto Vehicle Miles Travelled | | Line H * Line I * Line J |

## Summary Results

| | | Current Year (2015) | Horizon (20 Years) | |
|---|---|---|---|---|
| 5 | Value of environmental benefits | $2,912,821 | $7,146,948 | Sum of lines 19, 30, 41, 52, 63, 74, 85 and 96 for current and applicable (if any) horizon |
| 6 | Annualized capital and operating cost of project | $43,624,158 | $43,624,158 | Mobility and Cost Effectiveness Template, Line 6 |
| 7 | Ratio of environmental benefits to annualized cost | 6.7% | 16.4% | Line 5 / Line 6 |
| 8 | Value used in rating | 11.5% | | If a 10- or 20-year horizon is being used: 50 percent * Line 7 current year value + 50 percent * Line 7 horizon year value<br>If no horizon year is being used: Line 7 current year value |
| | | HIGH | | |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 2)

## VALUE OF BENEFITS BY FACTOR

### Air Quality: Carbon Monoxide (CO)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 9 | **Automobile** | 10,603,277 | 0.01677 | 177,816.95 | $0.10 | **$17,781.69** | --- | 0.01146 | --- | $0.10 | --- | 27,903,359 | 0.01026 | 286,288.47 | $0.10 | **$28,628.85** |
| 10 | **Diesel Bus** | 0 | 0.00583 | 0.00 | $0.10 | **$0.00** | --- | 0.00326 | --- | $0.10 | --- | 0 | 0.00289 | 0.00 | $0.10 | **$0.00** |
| 11 | **Hybrid Bus** | 0 | 0.00583 | 0.00 | $0.10 | **$0.00** | --- | 0.00326 | --- | $0.10 | --- | 0 | 0.00289 | 0.00 | $0.10 | **$0.00** |
| 12 | **CNG Bus** | 0 | 0.03962 | 0.00 | $0.10 | **$0.00** | --- | 0.02030 | --- | $0.10 | --- | 0 | 0.01716 | 0.00 | $0.10 | **$0.00** |
| 13 | **Electric Bus** | 0 | 0.00645 | 0.00 | $0.10 | **$0.00** | --- | 0.00539 | --- | $0.10 | --- | 0 | 0.00504 | 0.00 | $0.10 | **$0.00** |
| 14 | **Heavy Rail** | 0 | 0.00706 | 0.00 | $0.10 | **$0.00** | --- | 0.00685 | --- | $0.10 | --- | 0 | 0.00673 | 0.00 | $0.10 | **$0.00** |
| 15 | **Light Rail / Streetcar** | 0 | 0.01051 | 0.00 | $0.10 | **$0.00** | --- | 0.01020 | --- | $0.10 | --- | 0 | 0.01001 | 0.00 | $0.10 | **$0.00** |
| 16 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** | --- | 0.01680 | --- | $0.10 | --- | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** |
| 17 | **Commuter Rail - Used diesel locomotive** | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** | --- | 0.01680 | --- | $0.10 | --- | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** |
| 18 | **Commuter Rail - Electric or EMU** | 0 | 0.01281 | 0.00 | $0.10 | **$0.00** | --- | 0.01243 | --- | $0.10 | --- | 0 | 0.01219 | 0.00 | $0.10 | **$0.00** |
| 19 | **TOTAL CHANGE** | **10,603,277** | --- | **177,816.95** | --- | **$17,781.69** | --- | --- | --- | --- | --- | **27,903,359** | --- | **286,288.47** | --- | **$28,628.85** |

### Air Quality: Mono-Nitrogen Oxides ($NO_x$)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 20 | **Automobile** | 10,603,277 | 0.00091 | 9,648.98 | $16.20 | **$156,313.50** | --- | 0.00028 | --- | $19.58 | --- | 27,903,359 | 0.00020 | 5,580.67 | $20.25 | **$113,008.61** |
| 21 | **Diesel Bus** | 0 | 0.00867 | 0.00 | $16.20 | **$0.00** | --- | 0.00208 | --- | $19.58 | --- | 0 | 0.00114 | 0.00 | $20.25 | **$0.00** |
| 22 | **Hybrid Bus** | 0 | 0.00867 | 0.00 | $16.20 | **$0.00** | --- | 0.00208 | --- | $19.58 | --- | 0 | 0.00114 | 0.00 | $20.25 | **$0.00** |
| 23 | **CNG Bus** | 0 | 0.00384 | 0.00 | $16.20 | **$0.00** | --- | 0.00341 | --- | $19.58 | --- | 0 | 0.00335 | 0.00 | $20.25 | **$0.00** |
| 24 | **Electric Bus** | 0 | 0.00583 | 0.00 | $22.95 | **$0.00** | --- | 0.00439 | --- | $28.69 | --- | 0 | 0.00398 | 0.00 | $29.70 | **$0.00** |
| 25 | **Heavy Rail** | 0 | 0.00638 | 0.00 | $22.95 | **$0.00** | --- | 0.00558 | --- | $28.69 | --- | 0 | 0.00532 | 0.00 | $29.70 | **$0.00** |
| 26 | **Light Rail / Streetcar** | 0 | 0.00950 | 0.00 | $22.95 | **$0.00** | --- | 0.00831 | --- | $28.69 | --- | 0 | 0.00791 | 0.00 | $29.70 | **$0.00** |
| 27 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.01320 | 0.00 | $16.20 | **$0.00** | --- | 0.01320 | --- | $19.58 | --- | 0 | 0.01320 | 0.00 | $20.25 | **$0.00** |
| 28 | **Commuter Rail - Used diesel locomotive** | 0 | 0.09300 | 0.00 | $16.20 | **$0.00** | --- | 0.04300 | --- | $19.58 | --- | 0 | 0.02090 | 0.00 | $20.25 | **$0.00** |
| 29 | **Commuter Rail - Electric or EMU** | 0 | 0.01157 | 0.00 | $22.95 | **$0.00** | --- | 0.01012 | --- | $28.69 | --- | 0 | 0.00964 | 0.00 | $29.70 | **$0.00** |
| 30 | **TOTAL CHANGE** | **10,603,277** | --- | **9,648.98** | --- | **$156,313.50** | --- | --- | --- | --- | --- | **27,903,359** | --- | **5,580.67** | --- | **$113,008.61** |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 3)

## Air Quality: Volatile Organic Compounds (VOCs)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 31 | **Automobile** | 10,603,277 | 0.00060 | 6,361.97 | $4.53 | **$28,819.71** | --- | 0.00027 | --- | $5.63 | **---** | 27,903,359 | 0.00021 | 5,859.71 | $5.84 | **$34,220.68** |
| 32 | **Diesel Bus** | 0 | 0.00073 | 0.00 | $4.53 | **$0.00** | --- | 0.00024 | --- | $5.63 | **---** | 0 | 0.00016 | 0.00 | $5.84 | **$0.00** |
| 33 | **Hybrid Bus** | 0 | 0.00073 | 0.00 | $4.53 | **$0.00** | --- | 0.00024 | --- | $5.63 | **---** | 0 | 0.00016 | 0.00 | $5.84 | **$0.00** |
| 34 | **CNG Bus** | 0 | 0.00146 | 0.00 | $4.53 | **$0.00** | --- | 0.00115 | --- | $5.63 | **---** | 0 | 0.00111 | 0.00 | $5.84 | **$0.00** |
| 35 | **Electric Bus** | 0 | 0.00012 | 0.00 | $4.53 | **$0.00** | --- | 0.00010 | --- | $5.63 | **---** | 0 | 0.00010 | 0.00 | $5.84 | **$0.00** |
| 36 | **Heavy Rail** | 0 | 0.00013 | 0.00 | $4.53 | **$0.00** | --- | 0.00013 | --- | $5.63 | **---** | 0 | 0.00013 | 0.00 | $5.84 | **$0.00** |
| 37 | **Light Rail / Streetcar** | 0 | 0.00019 | 0.00 | $4.53 | **$0.00** | --- | 0.00019 | --- | $5.63 | **---** | 0 | 0.00020 | 0.00 | $5.84 | **$0.00** |
| 38 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.00055 | 0.00 | $4.53 | **$0.00** | --- | 0.00055 | --- | $5.63 | **---** | 0 | 0.00055 | 0.00 | $5.84 | **$0.00** |
| 39 | **Commuter Rail - Used diesel locomotive** | 0 | 0.00436 | 0.00 | $4.53 | **$0.00** | --- | 0.00126 | --- | $5.63 | **---** | 0 | 0.00044 | 0.00 | $5.84 | **$0.00** |
| 40 | **Commuter Rail - Electric or EMU** | 0 | 0.00024 | 0.00 | $4.53 | **$0.00** | --- | 0.00023 | --- | $5.63 | **---** | 0 | 0.00024 | 0.00 | $5.84 | **$0.00** |
| 41 | **TOTAL CHANGE** | **10,603,277** | **---** | **6,361.97** | **---** | **$28,819.71** | **---** | **---** | **---** | **---** | **---** | **27,903,359** | **---** | **5,859.71** | **---** | **$34,220.68** |

## Air Quality: Particulate Matter ($PM_{2.5}$)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 42 | **Automobile** | 10,603,277 | 0.000010 | 106.03 | $850.50 | **$90,180.87** | --- | 0.000010 | --- | $1,076.63 | **---** | 27,903,359 | 0.000010 | 279.03 | $1,120.50 | **$312,657.14** |
| 43 | **Diesel Bus** | 0 | 0.000480 | 0.00 | $850.50 | **$0.00** | --- | 0.000090 | --- | $1,076.63 | **---** | 0 | 0.000030 | 0.00 | $1,120.50 | **$0.00** |
| 44 | **Hybrid Bus** | 0 | 0.000480 | 0.00 | $850.50 | **$0.00** | --- | 0.000090 | --- | $1,076.63 | **---** | 0 | 0.000030 | 0.00 | $1,120.50 | **$0.00** |
| 45 | **CNG Bus** | 0 | 0.000010 | 0.00 | $850.50 | **$0.00** | --- | 0.000010 | --- | $1,076.63 | **---** | 0 | 0.000010 | 0.00 | $1,120.50 | **$0.00** |
| 46 | **Electric Bus** | 0 | 0.000378 | 0.00 | $702.00 | **$0.00** | --- | 0.000313 | --- | $860.63 | **---** | 0 | 0.000299 | 0.00 | $891.00 | **$0.00** |
| 47 | **Heavy Rail** | 0 | 0.000413 | 0.00 | $702.00 | **$0.00** | --- | 0.000398 | --- | $860.63 | **---** | 0 | 0.000399 | 0.00 | $891.00 | **$0.00** |
| 48 | **Light Rail / Streetcar** | 0 | 0.000615 | 0.00 | $702.00 | **$0.00** | --- | 0.000593 | --- | $860.63 | **---** | 0 | 0.000593 | 0.00 | $891.00 | **$0.00** |
| 49 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.000190 | 0.00 | $850.50 | **$0.00** | --- | 0.000190 | --- | $1,076.63 | **---** | 0 | 0.000190 | 0.00 | $1,120.50 | **$0.00** |
| 50 | **Commuter Rail - Used diesel locomotive** | 0 | 0.004600 | 0.00 | $850.50 | **$0.00** | --- | 0.001330 | --- | $1,076.63 | **---** | 0 | 0.000470 | 0.00 | $1,120.50 | **$0.00** |
| 51 | **Commuter Rail - Electric or EMU** | 0 | 0.000750 | 0.00 | $702.00 | **$0.00** | --- | 0.000722 | --- | $860.63 | **---** | 0 | 0.000723 | 0.00 | $891.00 | **$0.00** |
| 52 | **TOTAL CHANGE** | **10,603,277** | **---** | **106.03** | **---** | **$90,180.87** | **---** | **---** | **---** | **---** | **---** | **27,903,359** | **---** | **279.03** | **---** | **$312,657.14** |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 4)

## Greenhouse Gases (Carbon Dioxide Equivalent [$CO_2e$])

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (ton) / VMT | Emissions Decrease (Increase) (tons) | Monetization Factor ($ / ton) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (ton) / VMT | Emissions Decrease (Increase) (tons) | Monetization Factor ($ / ton) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (ton) / VMT | Emissions Decrease (Increase) (tons) | Monetization Factor ($ / ton) | Value of Improvement [1] |
| 53 | **Automobile** | 10,603,277 | 0.000532 | 5,640.94 | $38.00 | **$214,355.84** | --- | 0.000434 | --- | $38.00 | --- | 27,903,359 | 0.000397 | 11,077.63 | $38.00 | **$420,950.08** |
| 54 | **Diesel Bus** | 0 | 0.003319 | 0.00 | $38.00 | **$0.00** | --- | 0.002854 | --- | $38.00 | --- | 0 | 0.002721 | 0.00 | $38.00 | **$0.00** |
| 55 | **Hybrid Bus** | 0 | 0.002655 | 0.00 | $38.00 | **$0.00** | --- | 0.002283 | --- | $38.00 | --- | 0 | 0.002177 | 0.00 | $38.00 | **$0.00** |
| 56 | **CNG Bus** | 0 | 0.002935 | 0.00 | $38.00 | **$0.00** | --- | 0.002524 | --- | $38.00 | --- | 0 | 0.002406 | 0.00 | $38.00 | **$0.00** |
| 57 | **Electric Bus** | 0 | 0.002934 | 0.00 | $38.00 | **$0.00** | --- | 0.002441 | --- | $38.00 | --- | 0 | 0.002303 | 0.00 | $38.00 | **$0.00** |
| 58 | **Heavy Rail** | 0 | 0.003211 | 0.00 | $38.00 | **$0.00** | --- | 0.003106 | --- | $38.00 | --- | 0 | 0.003073 | 0.00 | $38.00 | **$0.00** |
| 59 | **Light Rail / Streetcar** | 0 | 0.004779 | 0.00 | $38.00 | **$0.00** | --- | 0.004623 | --- | $38.00 | --- | 0 | 0.004574 | 0.00 | $38.00 | **$0.00** |
| 60 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** | --- | 0.007970 | --- | $38.00 | --- | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** |
| 61 | **Commuter Rail - Used diesel locomotive** | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** | --- | 0.007970 | --- | $38.00 | --- | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** |
| 62 | **Commuter Rail - Electric or EMU** | 0 | 0.005821 | 0.00 | $38.00 | **$0.00** | --- | 0.005632 | --- | $38.00 | --- | 0 | 0.005572 | 0.00 | $38.00 | **$0.00** |
| 63 | **TOTAL CHANGE** | **10,603,277** | --- | **5,640.94** | --- | **$214,355.84** | --- | --- | --- | --- | --- | **27,903,359** | --- | **11,077.63** | --- | **$420,950.08** |

## Energy Use (British Thermal Units [Btu])

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Energy Use (million Btu) / VMT | Energy Use Decrease (Increase) (million Btu) | Monetization Factor ($ / million Btu) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Energy Use (million Btu) / VMT | Energy Use Decrease (Increase) (million Btu) | Monetization Factor ($ / million Btu) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Energy Use (million Btu) / VMT | Energy Use Decrease (Increase) (million Btu) | Monetization Factor ($ / million Btu) | Value of Improvement [1] |
| 64 | **Automobile** | 10,603,277 | 0.007559 | 80,150.17 | $1.72 | **$137,858.29** | --- | 0.006167 | --- | $1.72 | --- | 27,903,359 | 0.005633 | 157,179.62 | $1.72 | **$270,348.95** |
| 65 | **Diesel Bus** | 0 | 0.041436 | 0.00 | $1.56 | **$0.00** | --- | 0.035635 | --- | $1.56 | --- | 0 | 0.033978 | 0.00 | $1.56 | **$0.00** |
| 66 | **Hybrid Bus** | 0 | 0.033149 | 0.00 | $1.56 | **$0.00** | --- | 0.028508 | --- | $1.56 | --- | 0 | 0.027182 | 0.00 | $1.56 | **$0.00** |
| 67 | **CNG Bus** | | | | | | | | | | | | | | | |
| 68 | **Electric Bus** | | | | | | | | | | | | | | | |
| 69 | **Heavy Rail** | | | | | | | | | | | | | | | |
| 70 | **Light Rail / Streetcar** | | | | | | | | | | | | | | | |
| 71 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** | --- | 0.096138 | --- | $1.56 | --- | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** |
| 72 | **Commuter Rail - Used diesel locomotive** | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** | --- | 0.096138 | --- | $1.56 | --- | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** |
| 73 | **Commuter Rail - Electric or EMU** | | | | | | | | | | | | | | | |
| 74 | **TOTAL CHANGE** | **10,603,277** | --- | **80,150.17** | --- | **$137,858.29** | --- | --- | --- | --- | --- | **27,903,359** | --- | **157,179.62** | --- | **$270,348.95** |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 5)

## Safety: Fatalities

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Fatalities / VMT | Fatality Decrease (Increase) | Monetization Factor ($ / fatality) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Fatalities / VMT | Fatality Decrease (Increase) | Monetization Factor ($ / fatality) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Fatalities / VMT | Fatality Decrease (Increase) | Monetization Factor ($ / fatality) | Value of Improvement [1] |
| 75 | Automobile | 10,603,277 | 0.000000013 | 0.14 | $9,100,000 | **$1,254,367.62** | --- | 0.000000013 | --- | $9,100,000 | --- | 27,903,359 | 0.000000013 | 0.36 | $9,100,000 | **$3,300,967.42** |
| 76 | Diesel Bus | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | --- | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 77 | Hybrid Bus | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | --- | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 78 | CNG Bus | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | --- | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 79 | Electric Bus | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | --- | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 80 | Heavy Rail | 0 | 0.000000007 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000007 | --- | $9,100,000 | --- | 0 | 0.000000007 | 0.00 | $9,100,000 | **$0.00** |
| 81 | Light Rail / Streetcar | 0 | 0.000000009 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000009 | --- | $9,100,000 | --- | 0 | 0.000000009 | 0.00 | $9,100,000 | **$0.00** |
| 82 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000012 | --- | $9,100,000 | --- | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** |
| 83 | Commuter Rail - Used diesel locomotive | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000012 | --- | $9,100,000 | --- | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** |
| 84 | Commuter Rail - Electric or EMU | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000012 | --- | $9,100,000 | --- | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** |
| 85 | TOTAL CHANGE | **10,603,277** | --- | **0.14** | --- | **$1,254,367.62** | --- | --- | --- | --- | --- | **27,903,359** | --- | **0.36** | --- | **$3,300,967.42** |

## Safety: Injuries

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Injuries / VMT | Injury Decrease (Increase) | Monetization Factor ($ / injury) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Injuries / VMT | Injury Decrease (Increase) | Monetization Factor ($ / injury) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Injuries / VMT | Injury Decrease (Increase) | Monetization Factor ($ / injury) | Value of Improvement [1] |
| 86 | Automobile | 10,603,277 | 0.000000195 | 2.07 | $490,000 | **$1,013,143.08** | --- | 0.000000195 | --- | $490,000 | --- | 27,903,359 | 0.000000195 | 5.44 | $490,000 | **$2,666,165.99** |
| 87 | Diesel Bus | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** | --- | 0.000001824 | --- | $490,000 | --- | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** |
| 88 | Hybrid Bus | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** | --- | 0.000001824 | --- | $490,000 | --- | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** |
| 89 | CNG Bus | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** | --- | 0.000001824 | --- | $490,000 | --- | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** |
| 90 | Electric Bus | 0 | 0.000001458 | 0.00 | $490,000 | **$0.00** | --- | 0.000001458 | --- | $490,000 | --- | 0 | 0.000001458 | 0.00 | $490,000 | **$0.00** |
| 91 | Heavy Rail | 0 | 0.000000155 | 0.00 | $490,000 | **$0.00** | --- | 0.000000155 | --- | $490,000 | --- | 0 | 0.000000155 | 0.00 | $490,000 | **$0.00** |
| 92 | Light Rail / Streetcar | 0 | 0.000001696 | 0.00 | $490,000 | **$0.00** | --- | 0.000001696 | --- | $490,000 | --- | 0 | 0.000001696 | 0.00 | $490,000 | **$0.00** |
| 93 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** | --- | 0.000001746 | --- | $490,000 | --- | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** |
| 94 | Commuter Rail - Used diesel locomotive | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** | --- | 0.000001746 | --- | $490,000 | --- | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** |
| 95 | Commuter Rail - Electric or EMU | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** | --- | 0.000001746 | --- | $490,000 | --- | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** |
| 96 | TOTAL CHANGE | **10,603,277** | --- | **2.07** | --- | **$1,013,143.08** | --- | --- | --- | --- | --- | **27,903,359** | --- | **5.44** | --- | **$2,666,165.99** |

[1] Value will be positive for decreases and negative for increases.

# NEW STARTS RATING ESTIMATION

**PROJECT NAME:** SEPTA Broad Street Subway Extension: Alt 2 - 13th St & Constitution Ave

Use this tool to calculate your New Starts project's potential overall rating. Enter a value from the drop down menu in each of the yellow cells based on the ratings you anticipate. *

## Project Justification

| Criterion | Weight | Estimated Rating | Source/Calculation |
|---|---|---|---|
| Mobility Improvements | 16.66% | MEDIUM | Mobility, Cost-Effectiveness, and Congestion Relief Templates |
| Cost Effectiveness | 16.66% | MEDIUM-LOW | |
| Congestion Relief | 16.66% | MEDIUM | |
| Environmental Benefits | 16.66% | HIGH | Environmental Benefits Template |
| Land Use | 16.66% | LOW | Enter your estimations of these ratings. See FTA's Guidelines for Land Use and Economic Development Effects on how FTA determines the ratings for these criteria. |
| Economic Development | 16.66% | MEDIUM | |
| Summary Rating | | MEDIUM | Ratings are assigned to each criterion on a five-point scale, with Low = 1, Medium-Low =2, Medium = 3, Medium-High = 4, and High = 5. Individual criterion ratings are then weighted 16.66% each to develop the summary Project Justification rating. |

## Local Financial Commitment

| Criterion | Weight | Estimated Rating | Source/Calculation |
|---|---|---|---|
| Current Financial Condition | 25% | MEDIUM | Enter your estimations of these ratings. See the Local Financial Commitment section in the New Starts chapter of the CIG Program Final Interim Policy Guidance for information on how FTA rates these factors. |
| Commitment of Capital and Operating Funds | 25% | MEDIUM | |
| Reasonableness of Financial Plan | 50% | MEDIUM | |
| New Starts Share (Please complete the Finance Template) | - | - | Finance Template |
| Summary Rating | | MEDIUM | Ratings are assigned to each subfactor on a five-point scale, with Low = 1, Medium-Low = 2, Medium = 3, Medium-High = 4, and High = 5. Individual subfactor ratings are then weighted as shown to develop the summary Local Financial Commitment rating. If the summary rating is at least Medium and the New Starts share is less than 50%, the summary rating is increased one level. |

| Estimated Overall Project Rating: (The Project Justification and Local Financial Commitment summary ratings are each weighted equally at 50%. However, both must be at least Medium to obtain a Medium or better overall rating.) | MEDIUM |
|---|---|

Link to CIG Program Guidance on the FTA Website

* FTA is providing this tool to help project sponsors understand how their projects might rate. Any anticipated ratings entered into this spreadsheet will not be used by FTA to inform the ratings that FTA assigns. All ratings automatically computed in the templates are subject to verification by FTA. FTA has sole responsibility for assigning project ratings according to the evaluation and rating framework described in the Capital Investment Grant Program Final Interim Policy Guidance.

# NEW STARTS TRAVEL FORECASTS TEMPLATE

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 3 - Broad St & Kitty Hawk Ave |
|---|---|

## Trips on the Project

| Line | Transit market | Trips made by: | Daily linked trips: Current Year (2015) | Daily linked trips: Horizon (20 Years) | Annualization factor | Annual linked trips (daily trips * annualization factor): Current Year (2015) | Annual linked trips (daily trips * annualization factor): Horizon (20 Years) | Brief description of the process used to develop travel forecasts (e.g., local model, FTA simplified national model, incremental data-driven method, direct demand model) |
|---|---|---|---|---|---|---|---|---|
| 1a | Modeled trips: home-based work (HBW) | Non-transit dependents | 4,704 | 4,465 | 365 | 1,717,106 | 1,629,725 | Local model |
| 1b | | Transit dependents | 6,886 | 5,985 | | 2,513,244 | 2,184,525 | |
| 2a | Modeled trips: all other trip purposes | Non-transit dependents | 248 | 235 | 365 | 90,374 | 85,775 | Local model |
| 2b | | Transit dependents | 362 | 315 | | 132,276 | 114,975 | |
| 3a | Special market 1 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 3b | | Transit dependents | | | | 0 | 0 | |
| 4a | Special market 2 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 4b | | Transit dependents | | | | 0 | 0 | |
| 5a | Special market 3 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 5b | | Transit dependents | | | | 0 | 0 | |
| 6a | Special market 4 (specify) | Non-transit dependents | | | | 0 | 0 | |
| 6b | | Transit dependents | | | | 0 | 0 | |
| 7a | Subtotal (lines 1 through 6) | Non-transit dependents | | | | 1,807,480 | 1,715,500 | |
| 7b | | Transit dependents | | | | 2,645,520 | 2,299,500 | |
| 8a | **Total annual linked trips with special markets (lines 7a through 7b)** | | | | | **4,453,000** | **4,015,000** | |
| 8b | **Total daily linked trips without special markets (lines 1a through 2b)** | | **12,200** | **11,000** | | | | |
| 9 | New transit trips | | 400 | 4,600 | | | | |

## Vehicle-Miles of Travel (VMT)

| Line | Mode / Technology | Daily VMT: Current Year (2015) No-build | Daily VMT: Current Year (2015) Build | Daily VMT: Horizon (20 Years) No-build | Daily VMT: Horizon (20 Years) Build | Annualization factor | Annual VMT: Current Year (2015) No-build | Annual VMT: Current Year (2015) Build | Annual VMT: Horizon (20 Years) No-build | Annual VMT: Horizon (20 Years) Build | VMT change (Build minus No-build VMT): Current Year (2015) | VMT change (Build minus No-build VMT): Horizon (20 Years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | Automobile | 95,456,016 | 95,436,716 | 251,200,041 | 251,149,252 | 365 | 34,841,445,714 | 34,834,401,205 | 91,688,015,038 | 91,669,476,856 | -7,044,509 | -18,538,182 |
| 11 | Diesel bus | | | | | | | | | | 0 | 0 |
| 12 | Hybrid bus | | | | | | | | | | 0 | 0 |
| 13 | CNG bus | | | | | | | | | | 0 | 0 |
| 14 | Electric bus | | | | | | | | | | 0 | 0 |
| 15 | Heavy rail [1] | | | | | | | | | | 0 | 0 |
| 16 | Light rail / streetcar [1] | | | | | | | | | | 0 | 0 |
| 17 | Commuter rail (new diesel locomotive or DMU) [1] | | | | | | | | | | 0 | 0 |
| 18 | Commuter rail (used diesel locomotive) [1] | | | | | | | | | | 0 | 0 |
| 19 | Commuter rail (electric or EMU) [1] | | | | | | | | | | 0 | 0 |

[1] For rail transit modes, report VMT in terms of total rail passenger car mileage, not train mileage. (As an illustration of the difference, the rail passenger car mileage for a commuter rail or heavy rail train with six passenger cars would be six times the train mileage.)

# NEW STARTS MOBILITY, COST-EFFECTIVENESS, AND CONGESTION RELIEF TEMPLATE

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 3 - Broad St & Kitty Hawk Ave |
|---|---|

## Mobility Improvements

| Line | Item | Values | | Source/Calculation |
|---|---|---|---|---|
| | | Current Year (2015) | Horizon (20 Years) | |
| 1 | Annual linked trips on the project with double weight for trips by transit-dependent persons | 7,098,520 | 6,314,500 | Travel Forecasts Template, Line 7a + 2 * Line 7b |
| 2 | Value used in rating | 6,706,510 | | If a 10- or 20-year horizon is used: 50 percent * Line 1 current year value + 50 percent * Line 1 horizon year value<br>If no horizon year is used: Line 1 current year value |
| | | MEDIUM | | |

## Cost Effectiveness

| Line | Item | Values | | Source/Calculation |
|---|---|---|---|---|
| | | Current Year (2015) | Horizon (20 Years) | |
| 3 | Annualized project capital cost excluding enrichments (constant 2016 dollars) | $42,720,343 | $42,720,343 | Source: SCC Build Annualized worksheets |
| 4 | Annual project operating and maintenance costs (constant 2016 dollars) | $3,728,360 | $3,728,360 | Source: O & M cost models (attach documentation) |
| 5 | Annual linked trips on the project | 4,453,000 | 4,015,000 | Travel Forecasts Template, Line 8a |
| 6 | Annualized project capital and operating cost excluding enrichments (constant 2016 dollars) | $46,448,703 | $46,448,703 | Line 3 + Line 4 |
| 7 | Annualized cost per annual linked trip on the project | $10.43 | $11.57 | Line 6 / Line 5 |
| 8 | Value used in rating | $11.00 | | If a 10- or 20-year horizon is used: 50 percent * Line 7 current year value + 50 percent * Line 7 horizon year value<br>If no horizon year is used: Line 7 current year value |
| | | MEDIUM-LOW | | |

## Congestion Relief

| Line | Item | Values | | Source/Calculation |
|---|---|---|---|---|
| | | Current Year (2015) | Horizon (20 Years) | |
| 9 | New Weekday Linked Transit Trips | 400 | 4,600 | Travel Forecasts Template, Line 9 |
| 10 | Value used in rating | 2,500 | | If a 10- or 20-year horizon is used: 50 percent * Line 7 current year value + 50 percent * Line 7 horizon year value<br>If no horizon year is used: Line 7 current year value |
| | | MEDIUM | | |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE

| PROJECT NAME: | SEPTA Broad Street Subway Extension: Alt 3 - Broad St & Kitty Hawk Ave |
|---|---|

## Attainment Status

| Line | Item | Values | Source/Calculation |
|---|---|---|---|
| 1 | Regional air quality attainment status, carbon monoxide (CO) | Maintenance | Source: EPA Green Book |
| 2 | Regional air quality attainment status, nitrogen dioxide ($NO_2$) | Maintenance | |
| 3 | Regional air quality attainment status, ozone ($O_3$) (2008 8-hour standard) | Nonattainment | |
| 4 | Regional air quality attainment status, particulate matter ($PM_{2.5}$) (2006 standard) | Maintenance | |

## ADDITIONAL ENVIRONMENTAL BENEFITS INPUTS REQUIRED FOR WARRANTED NEW STARTS PROJECTS ONLY

| Line | | Values | Source/Calculation |
|---|---|---|---|
| A | Existing Annual Transit Ridership in the Corridor Today | [redacted] | Input by project sponsor |
| B | Percentage Change in Corridor Annual Transit Vehicle Hours That Would Result from Implementation of the Proposed Project | | Input by project sponsor |
| C | Elasticity Factor | | TCRP Report 95, Traveler Response to Transportation System Changes: Transit Scheduling and Frequency (2004) |
| D | Estimated Increase in Annual Project Ridership | | Line A * Line B * Line C |
| E | Average share of transit users that previously drove | | Factor based on data from past projects in the CIG program |
| F | Estimated new transit ridership coming from autos | | Line D * Line E |
| G | Average auto occupany factor | | Nation-wide average for work trips from the 2009 National Household Travel Survey |
| H | Estimated decrease (increase) in auto trips | | Line F / Line G |
| I | Project Length | | From Project Description Template |
| J | Average trip length factor | | Factor based on data from past projects in the CIG program |
| K | Estimated decrease (increase) in Annual Auto Vehicle Miles Travelled | | Line H * Line I * Line J |

## Summary Results

| | | Current Year (2015) | Horizon (20 Years) | |
|---|---|---|---|---|
| 5 | Value of environmental benefits | $1,935,193 | $4,748,225 | Sum of lines 19, 30, 41, 52, 63, 74, 85 and 96 for current and applicable (if any) horizon |
| 6 | Annualized capital and operating cost of project | $46,448,703 | $46,448,703 | Mobility and Cost Effectiveness Template, Line 6 |
| 7 | Ratio of environmental benefits to annualized cost | 4.2% | 10.2% | Line 5 / Line 6 |
| 8 | Value used in rating | 7.2% | | If a 10- or 20-year horizon is being used: 50 percent * Line 7 current year value + 50 percent * Line 7 horizon year value<br>If no horizon year is being used: Line 7 current year value |
| | | MEDIUM-HIGH | | |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 2)

## VALUE OF BENEFITS BY FACTOR

### Air Quality: Carbon Monoxide (CO)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 9 | **Automobile** | 7,044,509 | 0.01677 | 118,136.42 | $0.10 | **$11,813.64** | --- | 0.01146 | --- | $0.10 | --- | 18,538,182 | 0.01026 | 190,201.75 | $0.10 | **$19,020.17** |
| 10 | **Diesel Bus** | 0 | 0.00583 | 0.00 | $0.10 | **$0.00** | --- | 0.00326 | --- | $0.10 | --- | 0 | 0.00289 | 0.00 | $0.10 | **$0.00** |
| 11 | **Hybrid Bus** | 0 | 0.00583 | 0.00 | $0.10 | **$0.00** | --- | 0.00326 | --- | $0.10 | --- | 0 | 0.00289 | 0.00 | $0.10 | **$0.00** |
| 12 | **CNG Bus** | 0 | 0.03962 | 0.00 | $0.10 | **$0.00** | --- | 0.02030 | --- | $0.10 | --- | 0 | 0.01716 | 0.00 | $0.10 | **$0.00** |
| 13 | **Electric Bus** | 0 | 0.00645 | 0.00 | $0.10 | **$0.00** | --- | 0.00539 | --- | $0.10 | --- | 0 | 0.00504 | 0.00 | $0.10 | **$0.00** |
| 14 | **Heavy Rail** | 0 | 0.00706 | 0.00 | $0.10 | **$0.00** | --- | 0.00685 | --- | $0.10 | --- | 0 | 0.00673 | 0.00 | $0.10 | **$0.00** |
| 15 | **Light Rail / Streetcar** | 0 | 0.01051 | 0.00 | $0.10 | **$0.00** | --- | 0.01020 | --- | $0.10 | --- | 0 | 0.01001 | 0.00 | $0.10 | **$0.00** |
| 16 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** | --- | 0.01680 | --- | $0.10 | --- | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** |
| 17 | **Commuter Rail - Used diesel locomotive** | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** | --- | 0.01680 | --- | $0.10 | --- | 0 | 0.01680 | 0.00 | $0.10 | **$0.00** |
| 18 | **Commuter Rail - Electric or EMU** | 0 | 0.01281 | 0.00 | $0.10 | **$0.00** | --- | 0.01243 | --- | $0.10 | --- | 0 | 0.01219 | 0.00 | $0.10 | **$0.00** |
| 19 | **TOTAL CHANGE** | **7,044,509** | --- | **118,136.42** | --- | **$11,813.64** | --- | --- | --- | --- | --- | **18,538,182** | --- | **190,201.75** | --- | **$19,020.17** |

### Air Quality: Mono-Nitrogen Oxides ($NO_x$)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 20 | **Automobile** | 7,044,509 | 0.00091 | 6,410.50 | $16.20 | **$103,850.15** | --- | 0.00028 | --- | $19.58 | --- | 18,538,182 | 0.00020 | 3,707.64 | $20.25 | **$75,079.64** |
| 21 | **Diesel Bus** | 0 | 0.00867 | 0.00 | $16.20 | **$0.00** | --- | 0.00208 | --- | $19.58 | --- | 0 | 0.00114 | 0.00 | $20.25 | **$0.00** |
| 22 | **Hybrid Bus** | 0 | 0.00867 | 0.00 | $16.20 | **$0.00** | --- | 0.00208 | --- | $19.58 | --- | 0 | 0.00114 | 0.00 | $20.25 | **$0.00** |
| 23 | **CNG Bus** | 0 | 0.00384 | 0.00 | $16.20 | **$0.00** | --- | 0.00341 | --- | $19.58 | --- | 0 | 0.00335 | 0.00 | $20.25 | **$0.00** |
| 24 | **Electric Bus** | 0 | 0.00583 | 0.00 | $22.95 | **$0.00** | --- | 0.00439 | --- | $28.69 | --- | 0 | 0.00398 | 0.00 | $29.70 | **$0.00** |
| 25 | **Heavy Rail** | 0 | 0.00638 | 0.00 | $22.95 | **$0.00** | --- | 0.00558 | --- | $28.69 | --- | 0 | 0.00532 | 0.00 | $29.70 | **$0.00** |
| 26 | **Light Rail / Streetcar** | 0 | 0.00950 | 0.00 | $22.95 | **$0.00** | --- | 0.00831 | --- | $28.69 | --- | 0 | 0.00791 | 0.00 | $29.70 | **$0.00** |
| 27 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.01320 | 0.00 | $16.20 | **$0.00** | --- | 0.01320 | --- | $19.58 | --- | 0 | 0.01320 | 0.00 | $20.25 | **$0.00** |
| 28 | **Commuter Rail - Used diesel locomotive** | 0 | 0.09300 | 0.00 | $16.20 | **$0.00** | --- | 0.04300 | --- | $19.58 | --- | 0 | 0.02090 | 0.00 | $20.25 | **$0.00** |
| 29 | **Commuter Rail - Electric or EMU** | 0 | 0.01157 | 0.00 | $22.95 | **$0.00** | --- | 0.01012 | --- | $28.69 | --- | 0 | 0.00964 | 0.00 | $29.70 | **$0.00** |
| 30 | **TOTAL CHANGE** | **7,044,509** | --- | **6,410.50** | --- | **$103,850.15** | --- | --- | --- | --- | --- | **18,538,182** | --- | **3,707.64** | --- | **$75,079.64** |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 3)

## Air Quality: Volatile Organic Compounds (VOCs)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 31 | Automobile | 7,044,509 | 0.00060 | 4,226.71 | $4.53 | **$19,146.98** | --- | 0.00027 | --- | $5.63 | --- | 18,538,182 | 0.00021 | 3,893.02 | $5.84 | **$22,735.23** |
| 32 | Diesel Bus | 0 | 0.00073 | 0.00 | $4.53 | **$0.00** | --- | 0.00024 | --- | $5.63 | --- | 0 | 0.00016 | 0.00 | $5.84 | **$0.00** |
| 33 | Hybrid Bus | 0 | 0.00073 | 0.00 | $4.53 | **$0.00** | --- | 0.00024 | --- | $5.63 | --- | 0 | 0.00016 | 0.00 | $5.84 | **$0.00** |
| 34 | CNG Bus | 0 | 0.00146 | 0.00 | $4.53 | **$0.00** | --- | 0.00115 | --- | $5.63 | --- | 0 | 0.00111 | 0.00 | $5.84 | **$0.00** |
| 35 | Electric Bus | 0 | 0.00012 | 0.00 | $4.53 | **$0.00** | --- | 0.00010 | --- | $5.63 | --- | 0 | 0.00010 | 0.00 | $5.84 | **$0.00** |
| 36 | Heavy Rail | 0 | 0.00013 | 0.00 | $4.53 | **$0.00** | --- | 0.00013 | --- | $5.63 | --- | 0 | 0.00013 | 0.00 | $5.84 | **$0.00** |
| 37 | Light Rail / Streetcar | 0 | 0.00019 | 0.00 | $4.53 | **$0.00** | --- | 0.00019 | --- | $5.63 | --- | 0 | 0.00020 | 0.00 | $5.84 | **$0.00** |
| 38 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.00055 | 0.00 | $4.53 | **$0.00** | --- | 0.00055 | --- | $5.63 | --- | 0 | 0.00055 | 0.00 | $5.84 | **$0.00** |
| 39 | Commuter Rail - Used diesel locomotive | 0 | 0.00436 | 0.00 | $4.53 | **$0.00** | --- | 0.00126 | --- | $5.63 | --- | 0 | 0.00044 | 0.00 | $5.84 | **$0.00** |
| 40 | Commuter Rail - Electric or EMU | 0 | 0.00024 | 0.00 | $4.53 | **$0.00** | --- | 0.00023 | --- | $5.63 | --- | 0 | 0.00024 | 0.00 | $5.84 | **$0.00** |
| 41 | **TOTAL CHANGE** | **7,044,509** | **---** | **4,226.71** | **---** | **$19,146.98** | **---** | **---** | **---** | **---** | **---** | **18,538,182** | **---** | **3,893.02** | **---** | **$22,735.23** |

## Air Quality: Particulate Matter ($PM_{2.5}$)

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (kg) / VMT | Emissions Decrease (Increase) (kg) | Monetization Factor ($ / kg) | Value of Improvement [1] |
| 42 | Automobile | 7,044,509 | 0.000010 | 70.45 | $850.50 | **$59,913.55** | --- | 0.000010 | --- | $1,076.63 | --- | 18,538,182 | 0.000010 | 185.38 | $1,120.50 | **$207,720.33** |
| 43 | Diesel Bus | 0 | 0.000480 | 0.00 | $850.50 | **$0.00** | --- | 0.000090 | --- | $1,076.63 | --- | 0 | 0.000030 | 0.00 | $1,120.50 | **$0.00** |
| 44 | Hybrid Bus | 0 | 0.000480 | 0.00 | $850.50 | **$0.00** | --- | 0.000090 | --- | $1,076.63 | --- | 0 | 0.000030 | 0.00 | $1,120.50 | **$0.00** |
| 45 | CNG Bus | 0 | 0.000010 | 0.00 | $850.50 | **$0.00** | --- | 0.000010 | --- | $1,076.63 | --- | 0 | 0.000010 | 0.00 | $1,120.50 | **$0.00** |
| 46 | Electric Bus | 0 | 0.000378 | 0.00 | $702.00 | **$0.00** | --- | 0.000313 | --- | $860.63 | --- | 0 | 0.000299 | 0.00 | $891.00 | **$0.00** |
| 47 | Heavy Rail | 0 | 0.000413 | 0.00 | $702.00 | **$0.00** | --- | 0.000398 | --- | $860.63 | --- | 0 | 0.000399 | 0.00 | $891.00 | **$0.00** |
| 48 | Light Rail / Streetcar | 0 | 0.000615 | 0.00 | $702.00 | **$0.00** | --- | 0.000593 | --- | $860.63 | --- | 0 | 0.000593 | 0.00 | $891.00 | **$0.00** |
| 49 | Commuter Rail - New diesel locomotive or DMU | 0 | 0.000190 | 0.00 | $850.50 | **$0.00** | --- | 0.000190 | --- | $1,076.63 | --- | 0 | 0.000190 | 0.00 | $1,120.50 | **$0.00** |
| 50 | Commuter Rail - Used diesel locomotive | 0 | 0.004600 | 0.00 | $850.50 | **$0.00** | --- | 0.001330 | --- | $1,076.63 | --- | 0 | 0.000470 | 0.00 | $1,120.50 | **$0.00** |
| 51 | Commuter Rail - Electric or EMU | 0 | 0.000750 | 0.00 | $702.00 | **$0.00** | --- | 0.000722 | --- | $860.63 | --- | 0 | 0.000723 | 0.00 | $891.00 | **$0.00** |
| 52 | **TOTAL CHANGE** | **7,044,509** | **---** | **70.45** | **---** | **$59,913.55** | **---** | **---** | **---** | **---** | **---** | **18,538,182** | **---** | **185.38** | **---** | **$207,720.33** |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 4)

## Greenhouse Gases (Carbon Dioxide Equivalent [$CO_2e$])

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Emissions (ton) / VMT | Emissions Decrease (Increase) (tons) | Monetization Factor ($ / ton) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (ton) / VMT | Emissions Decrease (Increase) (tons) | Monetization Factor ($ / ton) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Emissions (ton) / VMT | Emissions Decrease (Increase) (tons) | Monetization Factor ($ / ton) | Value of Improvement [1] |
| 53 | **Automobile** | 7,044,509 | 0.000532 | 3,747.68 | $38.00 | **$142,411.80** | --- | 0.000434 | --- | $38.00 | **---** | 18,538,182 | 0.000397 | 7,359.66 | $38.00 | **$279,667.02** |
| 54 | **Diesel Bus** | 0 | 0.003319 | 0.00 | $38.00 | **$0.00** | --- | 0.002854 | --- | $38.00 | **---** | 0 | 0.002721 | 0.00 | $38.00 | **$0.00** |
| 55 | **Hybrid Bus** | 0 | 0.002655 | 0.00 | $38.00 | **$0.00** | --- | 0.002283 | --- | $38.00 | **---** | 0 | 0.002177 | 0.00 | $38.00 | **$0.00** |
| 56 | **CNG Bus** | 0 | 0.002935 | 0.00 | $38.00 | **$0.00** | --- | 0.002524 | --- | $38.00 | **---** | 0 | 0.002406 | 0.00 | $38.00 | **$0.00** |
| 57 | **Electric Bus** | 0 | 0.002934 | 0.00 | $38.00 | **$0.00** | --- | 0.002441 | --- | $38.00 | **---** | 0 | 0.002303 | 0.00 | $38.00 | **$0.00** |
| 58 | **Heavy Rail** | 0 | 0.003211 | 0.00 | $38.00 | **$0.00** | --- | 0.003106 | --- | $38.00 | **---** | 0 | 0.003073 | 0.00 | $38.00 | **$0.00** |
| 59 | **Light Rail / Streetcar** | 0 | 0.004779 | 0.00 | $38.00 | **$0.00** | --- | 0.004623 | --- | $38.00 | **---** | 0 | 0.004574 | 0.00 | $38.00 | **$0.00** |
| 60 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** | --- | 0.007970 | --- | $38.00 | **---** | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** |
| 61 | **Commuter Rail - Used diesel locomotive** | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** | --- | 0.007970 | --- | $38.00 | **---** | 0 | 0.007970 | 0.00 | $38.00 | **$0.00** |
| 62 | **Commuter Rail - Electric or EMU** | 0 | 0.005821 | 0.00 | $38.00 | **$0.00** | --- | 0.005632 | --- | $38.00 | **---** | 0 | 0.005572 | 0.00 | $38.00 | **$0.00** |
| 63 | **TOTAL CHANGE** | **7,044,509** | **---** | **3,747.68** | **---** | **$142,411.80** | **---** | **---** | **---** | **---** | **---** | **18,538,182** | **---** | **7,359.66** | **---** | **$279,667.02** |

## Energy Use (British Thermal Units [Btu])

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Energy Use (million Btu) / VMT | Energy Use Decrease (Increase) (million Btu) | Monetization Factor ($ / million Btu) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Energy Use (million Btu) / VMT | Energy Use Decrease (Increase) (million Btu) | Monetization Factor ($ / million Btu) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Energy Use (million Btu) / VMT | Energy Use Decrease (Increase) (million Btu) | Monetization Factor ($ / million Btu) | Value of Improvement [1] |
| 64 | **Automobile** | 7,044,509 | 0.007559 | 53,249.45 | $1.72 | **$91,589.05** | --- | 0.006167 | --- | $1.72 | **---** | 18,538,182 | 0.005633 | 104,425.58 | $1.72 | **$179,612.00** |
| 65 | **Diesel Bus** | 0 | 0.041436 | 0.00 | $1.56 | **$0.00** | --- | 0.035635 | --- | $1.56 | **---** | 0 | 0.033978 | 0.00 | $1.56 | **$0.00** |
| 66 | **Hybrid Bus** | 0 | 0.033149 | 0.00 | $1.56 | **$0.00** | --- | 0.028508 | --- | $1.56 | **---** | 0 | 0.027182 | 0.00 | $1.56 | **$0.00** |
| 67 | **CNG Bus** | | | | | | | | | | | | | | | |
| 68 | **Electric Bus** | | | | | | | | | | | | | | | |
| 69 | **Heavy Rail** | | | | | | | | | | | | | | | |
| 70 | **Light Rail / Streetcar** | | | | | | | | | | | | | | | |
| 71 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** | --- | 0.096138 | --- | $1.56 | **---** | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** |
| 72 | **Commuter Rail - Used diesel locomotive** | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** | --- | 0.096138 | --- | $1.56 | **---** | 0 | 0.096138 | 0.00 | $1.56 | **$0.00** |
| 73 | **Commuter Rail - Electric or EMU** | | | | | | | | | | | | | | | |
| 74 | **TOTAL CHANGE** | **7,044,509** | **---** | **53,249.45** | **---** | **$91,589.05** | **---** | **---** | **---** | **---** | **---** | **18,538,182** | **---** | **104,425.58** | **---** | **$179,612.00** |

# NEW STARTS ENVIRONMENTAL BENEFITS TEMPLATE (page 5)

## Safety: Fatalities

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Fatalities / VMT | Fatality Decrease (Increase) | Monetization Factor ($ / fatality) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Fatalities / VMT | Fatality Decrease (Increase) | Monetization Factor ($ / fatality) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Fatalities / VMT | Fatality Decrease (Increase) | Monetization Factor ($ / fatality) | Value of Improvement [1] |
| 75 | **Automobile** | 7,044,509 | 0.000000013 | 0.09 | $9,100,000 | **$833,365.44** | --- | 0.000000013 | --- | $9,100,000 | **---** | 18,538,182 | 0.000000013 | 0.24 | $9,100,000 | **$2,193,066.94** |
| 76 | **Diesel Bus** | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | **---** | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 77 | **Hybrid Bus** | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | **---** | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 78 | **CNG Bus** | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | **---** | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 79 | **Electric Bus** | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000004 | --- | $9,100,000 | **---** | 0 | 0.000000004 | 0.00 | $9,100,000 | **$0.00** |
| 80 | **Heavy Rail** | 0 | 0.000000007 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000007 | --- | $9,100,000 | **---** | 0 | 0.000000007 | 0.00 | $9,100,000 | **$0.00** |
| 81 | **Light Rail / Streetcar** | 0 | 0.000000009 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000009 | --- | $9,100,000 | **---** | 0 | 0.000000009 | 0.00 | $9,100,000 | **$0.00** |
| 82 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000012 | --- | $9,100,000 | **---** | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** |
| 83 | **Commuter Rail - Used diesel locomotive** | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000012 | --- | $9,100,000 | **---** | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** |
| 84 | **Commuter Rail - Electric or EMU** | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** | --- | 0.000000012 | --- | $9,100,000 | **---** | 0 | 0.000000012 | 0.00 | $9,100,000 | **$0.00** |
| 85 | **TOTAL CHANGE** | **7,044,509** | **---** | **0.09** | **---** | **$833,365.44** | **---** | **---** | **---** | **---** | **---** | **18,538,182** | **---** | **0.24** | **---** | **$2,193,066.94** |

## Safety: Injuries

| Line | Mode | Current Year | | | | | Horizon - 10 Years | | | | | Horizon - 20 Years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VMT Decrease (Increase) | Conversion Factor: Injuries / VMT | Injury Decrease (Increase) | Monetization Factor ($ / injury) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Injuries / VMT | Injury Decrease (Increase) | Monetization Factor ($ / injury) | Value of Improvement [1] | VMT Decrease (Increase) | Conversion Factor: Injuries / VMT | Injury Decrease (Increase) | Monetization Factor ($ / injury) | Value of Improvement [1] |
| 86 | **Automobile** | 7,044,509 | 0.000000195 | 1.37 | $490,000 | **$673,102.85** | --- | 0.000000195 | --- | $490,000 | **---** | 18,538,182 | 0.000000195 | 3.61 | $490,000 | **$1,771,323.30** |
| 87 | **Diesel Bus** | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** | --- | 0.000001824 | --- | $490,000 | **---** | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** |
| 88 | **Hybrid Bus** | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** | --- | 0.000001824 | --- | $490,000 | **---** | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** |
| 89 | **CNG Bus** | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** | --- | 0.000001824 | --- | $490,000 | **---** | 0 | 0.000001824 | 0.00 | $490,000 | **$0.00** |
| 90 | **Electric Bus** | 0 | 0.000001458 | 0.00 | $490,000 | **$0.00** | --- | 0.000001458 | --- | $490,000 | **---** | 0 | 0.000001458 | 0.00 | $490,000 | **$0.00** |
| 91 | **Heavy Rail** | 0 | 0.000000155 | 0.00 | $490,000 | **$0.00** | --- | 0.000000155 | --- | $490,000 | **---** | 0 | 0.000000155 | 0.00 | $490,000 | **$0.00** |
| 92 | **Light Rail / Streetcar** | 0 | 0.000001696 | 0.00 | $490,000 | **$0.00** | --- | 0.000001696 | --- | $490,000 | **---** | 0 | 0.000001696 | 0.00 | $490,000 | **$0.00** |
| 93 | **Commuter Rail - New diesel locomotive or DMU** | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** | --- | 0.000001746 | --- | $490,000 | **---** | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** |
| 94 | **Commuter Rail - Used diesel locomotive** | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** | --- | 0.000001746 | --- | $490,000 | **---** | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** |
| 95 | **Commuter Rail - Electric or EMU** | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** | --- | 0.000001746 | --- | $490,000 | **---** | 0 | 0.000001746 | 0.00 | $490,000 | **$0.00** |
| 96 | **TOTAL CHANGE** | **7,044,509** | **---** | **1.37** | **---** | **$673,102.85** | **---** | **---** | **---** | **---** | **---** | **18,538,182** | **---** | **3.61** | **---** | **$1,771,323.30** |

[1] Value will be positive for decreases and negative for increases.

# NEW STARTS RATING ESTIMATION

**PROJECT NAME:** SEPTA Broad Street Subway Extension: Alt 3 - Broad St & Kitty Hawk Ave

Use this tool to calculate your New Starts project's potential overall rating. Enter a value from the drop down menu in each of the yellow cells based on the ratings you anticipate. *

## Project Justification

| Criterion | Weight | Estimated Rating | Source/Calculation |
|---|---|---|---|
| Mobility Improvements | 16.66% | MEDIUM | Mobility, Cost-Effectiveness, and Congestion Relief Templates |
| Cost Effectiveness | 16.66% | MEDIUM-LOW | |
| Congestion Relief | 16.66% | MEDIUM | |
| Environmental Benefits | 16.66% | MEDIUM-HIGH | Environmental Benefits Template |
| Land Use | 16.66% | LOW | Enter your estimations of these ratings. See FTA's Guidelines for Land Use and Economic Development Effects on how FTA determines the ratings for these criteria. |
| Economic Development | 16.66% | MEDIUM | |
| Summary Rating | | MEDIUM | Ratings are assigned to each criterion on a five-point scale, with Low = 1, Medium-Low =2, Medium = 3, Medium-High = 4, and High = 5. Individual criterion ratings are then weighted 16.66% each to develop the summary Project Justification rating. |

## Local Financial Commitment

| Criterion | Weight | Estimated Rating | Source/Calculation |
|---|---|---|---|
| Current Financial Condition | 25% | MEDIUM | Enter your estimations of these ratings. See the Local Financial Commitment section in the New Starts chapter of the CIG Program Final Interim Policy Guidance for information on how FTA rates these factors. |
| Commitment of Capital and Operating Funds | 25% | MEDIUM | |
| Reasonableness of Financial Plan | 50% | MEDIUM | |
| New Starts Share (Please complete the Finance Template) | - | - | Finance Template |
| Summary Rating | | MEDIUM | Ratings are assigned to each subfactor on a five-point scale, with Low = 1, Medium-Low = 2, Medium = 3, Medium-High = 4, and High = 5. Individual subfactor ratings are then weighted as shown to develop the summary Local Financial Commitment rating. If the summary rating is at least Medium and the New Starts share is less than 50%, the summary rating is increased one level. |

| Estimated Overall Project Rating: (The Project Justification and Local Financial Commitment summary ratings are each weighted equally at 50%. However, both must be at least Medium to obtain a Medium or better overall rating.) | MEDIUM |
|---|---|

Link to CIG Program Guidance on the FTA Website

* FTA is providing this tool to help project sponsors understand how their projects might rate. Any anticipated ratings entered into this spreadsheet will not be used by FTA to inform the ratings that FTA assigns. All ratings automatically computed in the templates are subject to verification by FTA. FTA has sole responsibility for assigning project ratings according to the evaluation and rating framework described in the Capital Investment Grant Program Final Interim Policy Guidance.

# APPENDIX G

BROAD STREET SUBWAY LINE EXTENSION TO THE NAVY YARD – TUNNEL, GEOTECHNICAL AND CONSTRUCTABILITY REPORT

**SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTHORITY**

GEC 14-B-30

# Broad Street Subway Extension to the Philadelphia Navy Yard

## Tunnel, Geotechnical and Constructability Review

**Final Technical Memorandum**

**February 22, 2019**

PREPARED FOR

**Southeastern Pennsylvania Transportation Authority**

PREPARED BY

**HNTB Corporation**

1650 Arch Street

Suite 1700

Philadelphia, PA 19103

# TABLE OF CONTENTS

# I. EXECUTIVE SUMMARY

The enclosed technical memorandum provides documentation of a review of the 2008 Extension Study (advanced by PIDC), an assessment of alternative construction methods and impacts, as well as a recommendation for the most cost-effective construction methods for this project as it is currently envisioned.

Based upon our review of available geotechnical information, and an evaluation of possible construction techniques, the recommended construction method for this project is to advance the tunnels using a tunnel boring machine (TBM). The stations will require cut-and-cover excavation. The tunneling approach was determined to be more cost-effective and less disruptive for this project as compared to alternative tunneling methods.

This information is intended to be used as supporting documentation for the Feasibility Study currently being advanced by PennDOT on behalf of SEPTA – this document is intended to serve as an appendix to the Final Report.

# II. PURPOSE

The purpose of this memorandum is to provide supporting documentation for the construction methods and techniques evaluated and recommended for the proposed SEPTA Broad Street Subway Extension to Philadelphia Navy Yard (BSLX). This includes a review of the 2008 Feasibility Study (completed by PIDC), an assessment of alternative construction methods, as well as recommendations around cost-effective construction techniques. This memorandum in intended to be incorporated into the overall Broad Street Subway Extension Report as an appendix.

# III. REVIEW OF 2008 STUDY

## III.1 GEOTECHNICAL EVALUATION

The 2008 Feasibility Study made several geotechnical assumptions including an overly optimistic interpretation of existing subsurface information. Based on these assumptions the study falls short in providing the most cost-effective solutions for the proposed Broad Street Line Extension. Furthermore, Appendix C-4 of the 2008 document includes commentary from an experienced member of the 2008 Study Team that calls into question the study's own findings, and therein corroborates HNTB's assessment of the geotechnical and groundwater conditions.

One such instance occurs under in the section entitled "*Ground Water*" in Appendix C-1. This section explains that recent subsurface investigations, including the 1996 SCE & Associates, 2006 Hunt Engineering, and 2007 Kleinfelder programs, identify groundwater being encountered at shallow depths within one to eight feet below the existing ground surface. The document goes on to say that this is likely perched water and not the actual ground water level, because the 1966 Kuljian Deleuw Cather report describes the organic silt stratum beneath the water readings as impermeable and that a lower ground water level was encountered between elevations -27 feet and -29 feet. It is this lower groundwater table that is used to determine the impacts of the groundwater on the construction including buoyancy and dewatering. Comment No. 8 in Appendix C-4 calls into question this claim and states that groundwater information over 50 years old may no longer be reliable and that more current information should be obtained. Also, the proximity of the site to the Delaware River indicates that the regional groundwater level should be close to the ground surface and probably tidally influenced.

In a cut and cover tunnel operation high groundwater levels pose a significant constructability issue. HNTB contends that groundwater is one of the greatest risks associated with this project

The base of the excavations will lay predominantly within the Trenton Gravel which is a highly pervious material. A cut and cover tunnel would require a tremendous amount of dewatering and multiple water treatment plants, or extensive ground improvements and support of excavation provided continuously along the tunnel alignment which would be cost prohibitive.

Additionally, the Trenton Gravel located at the base of the cut and cover excavation is very dense and contains an abundance of erratics such as cobbles and boulders. The 2008 Feasibility Study states that

sheet piling will be utilized as the support of excavation (SOE) system and will act as a cutoff for water infiltration into the excavation. Again, the commentary in Appendix C-4 of the study expresses concern over this claim, specifically Comment No. 11 states that sheet piling may not be suitable or economical for the deeper excavations or limited headroom associated with the project and may not be productive when driving into gravel.

HNTB does not recommend the use of sheet piling SOE, because it exposes the project to two other major risks. The first being the predominance of soft compressible estuarine and tidal marsh deposits, such as organic silt, which has very low undrained shear strengths and will impart significant lateral earth pressures on the SOE system. Based on a conceptual level design considering multiple SOE systems, traditional sheet piles would not have the required section modulus to resist these forces even with several rows of bracing. While the second risk relates to the drivability of the sheet piling. The relative density of the Trenton Gravel at the excavation base and presence of cobbles and boulders will preclude the sheeting from reaching its minimum tip elevation and would likely damage many of the sheet piles installed. In summary, risks associated with sheet pile SOE systems include high ground water table, soft and compressible organic silts, and pile drivability. These factors were not adequately captured within the 2008 Feasibility Study and would result in higher contractor bids as well as potentially dangerous construction conditions.

## III.2 EVALUATION OF CONSTRUCTION TECHNIQUES

The subsurface conditions along the subway alignment are challenging from a tunneling perspective. The surficial soils are miscellaneous fill materials, underlain by soft marine deposits, which are in turn underlain by a thick sequence of permeable, water bearing, granular soils. These conditions make cut and cover construction difficult. The stability of the base of any deep cut and cover excavation is a primary consideration. To avoid massive dewatering and its potential side effects, such as settlement and contaminant migration, the base of open cut excavations must be hydraulically sealed. Sealing such excavations will require that either that the support of excavation (SOE) walls be taken deep enough to intercept the impermeable Potomac Foundation Clay, the depth of which has not been clearly established, or expensive grouted soil seals will need to be provided. These considerations lead to an approach that limits cut and cover construction to only those portions of the alignment in need of a ‘box’ type structure, such as stations and storage track areas.

With cut and cover construction limited to stations, the tunnel portions of the alignment will require mined tunnel techniques. Although the Navy Yard Extension is not long in terms of tunneling, the cost premium associated with mobilizing tunnel mining equipment is offset by the reduced risks associated with extensive cut and cover construction.

The selection of the proper tunnel mining equipment, i.e. tunnel boring machine (TBM), is dependent upon the characteristics of the soil and groundwater to be encountered. For the Navy Yard alignment, the key parameters relate to the gradation and permeability of the site’s granular soils, the Trenton Gravels and other alluvial deposits. Typically, in highly permeable soils, closed-faced, slurry type TBMs are required to control the removal of such soils. A significant disadvantage with slurry shields is the complex

plant that is required to support the mining operation. This includes slurry pumps and piping, slurry filtering and cleaning equipment, and significant surface area to house this equipment. In recent years, advances have been made with closed-faced earth pressure balance (EPBM) TBMs with the use of soil binding additives. These additives have proven to be effective in all but the most permeable soils and thus allow for the use of the less complicated EPBM in granular soils. The selection of which TBM is best suited for the BSLX will require further testing of the granular soils to better define their permeability and gradation. For the purposes of the construction estimate, it has been assumed that an EPBM with ground modifying additives will be suitable for the alignment.

Another significant consideration for mined tunnels is underground obstructions and boulders. During the next phase of design, a comprehensive inventory of known and potential obstructions should be developed. Current and historic maps can indicate where previous pile supported structures may have existed and thus pose an obstruction. Such obstructions, such as timber piles, can be mined through, while others can be pulled or avoided with alignment adjustments.

Cross passages are required for passenger egress in the event of a tunnel fire, as per National Fire Protection Association Guideline 130 (NFPA-130). These are to be no more than 800 feet apart and provide connection to a non-incident tunnel. Cross passages under hydrostatic pressure have typically been constructed using ground improvement, such as jet grouting or freezing, between the tunnels. Passageways are then advanced using sequentially excavation methods with an initial shotcrete/lattice girder lining, waterproofing and then a final cast-in-place concrete lining. Recent advances in mechanized tunnel equipment allow for the construction of cross passages using a "mini-TBM". The mini-TBMs are launched from one tunnel and advanced and lined with precast concrete segments, until they intercept the adjacent tunnel. Limited ground treatment is required adjacent to the running tunnels to allow for the connection of the cross passage to the running tunnels.

## III.3 EVALUATION OF PREVIOUS CONSTRUCTION COST ESTIMATE

The 2008 Feasibility Study estimate was based on underground cut and cover guideway that would cross under I-95, an existing freight railroad line, and run under Rouse Boulevard, which had not yet been developed at the time of the study. The 2008 estimate included two stations with 1.5 miles of guideway for total cost of $371 million. The estimate was then escalated to 2015 dollars utilizing published escalation factors for a value of $435 million.

The 2008 study listed several construction issues related to cut and cover type construction including:

- Construction under I-95:

  "While no disruption to the roadways or temporary structures will be required, there may be requirements to underpin or provide stabilization of the pile supported piers for the roadway spans. This will be determined during preliminary engineering based on more detailed investigations of the depths and locations of the piles."

  *It is apparent that the support of excavation under I-95 is not accounted for in 2008 Study.*

- Construction under freight RR tracks:

  "The railroad tracks will need to remain in service during excavation and construction of the subway structure. This will require driving piles to serve as bridge piers/abutments and construction of temporary bridge spans across the excavation to support each of the four tracks…"

  *It is apparent that the support of excavation at the freight railroad tracks is not adequately accounted for in 2008 Study.*

- Utility conflicts in the Navy Yard:

  Since the 2008 Study, significant infrastructure (water, storm sewer, sanitary sewer, communications, etc.) has been installed and is operational. Gravity fed sewer lines cannot be rerouted without compromising function, so tunnel profile needs to be lowered. Utilities need to be kept operational during construction.

  *2008 estimate included only $648,000 for utility relocation*

In addition to the above, costs for hazardous materials, contaminated soils and groundwater treatment were excluded; all of which have a prohibitive cost impact using cut and cover construction.

Finally, the 2008 study did not include costs for a fan plant or account for means to provide subway operations during special events at the Sports Complex, which is critical to the service extension into the Navy Yard. It is estimated that the fan plant would add $20-30M to the overall cost of the project. The addition of tail tracks below NRG station to facilitate special event operations is estimated to add $50-75M to the overall cost of the project.

# IV. ALTERNATIVE CONSTRUCTION METHODS

## IV.1 GEOTECHNICAL CONDITIONS

HNTB has gathered available subsurface information from multiple sources including Client provided previous subsurface investigations provided by SEPTA, HNTB in-house project records, USGS Surficial Geology mapping, USGS Bedrock Geology mapping. Subsurface information provided by the SEPTA is summarized in the following table:

| Project Name | Performing Agency |
|---|---|
| I-95 Viaduct (1969) | Michael Baker |
| Philadelphia Naval Business Center (2004) | Powell-Harpstead |
| Diagonal Blvd., Intrepid Ave., and Normandy Pl. (2007) | Kleinfelder |
| Stock Exchange (1996) | SCE Associates |
| Broad Street Quay Wall Replacement | Matrix New World |
| Navy Yard Town Center (2006) | Hunt Engineering Company |

## SITE GEOLOGY

The SEPTA BSLX project site lies in the Coastal Plains Physiographic Province with surficial geology primarily attributed to the Wisconsinan glaciation. The project site generally consists of surficial miscellaneous, manmade fills underlain by estuarine and salt-marsh deposits, alluvial deposits and glaciofluvial sediments that are underlain by the Potomac Formation.

The surficial geology was derived from glacial melt waters during the Late Wisconsinan glaciation between approximately 20,000 and 15,000 years ago. The melt waters formed a terrace of glaciofluvial material along the Delaware River at a surface elevation of 10 feet to 15 feet. The glaciofluvial materials were later incised and reworked by alluvial sands from the postglacial Delaware River before the Holocene sea level rise entered the Delaware Valley approximately 10,000 years ago. Alluvial soils in some areas include pebble-to-cobble gravel derived, in part, from erosion and reworking of the upper portion of the glaciofluvial deposits.

Estuarine and salt-marsh sedimentation was deposited atop the alluvial soils as sea level rose and flooded the former lake plains which occurred approximately in the last 3,000 years. Artificial fill comprises the existing ground surface as landfilling on the marsh and alluvial deposits was performed to develop the Philadelphia Navy Yard.

Beneath the surficial deposits lie the geologically older deposits of the Coastal Plains associated with the Potomac Formation laid down in coastal, near shore marine, and continental shelf settings between 95 million and 75 million years ago. The Potomac Formation consists of interbedded layers of sand, silt and clay deposited alternately in deltaic and marine environments as sea level fluctuated during Cretaceous and Tertiary time. Clay and silt is white, yellow, brown, reddish-yellow where weathered, and gray to black where unweathered. Sand is coarse to fine with pebble-to-cobble gravel and ranging in color from white, yellow, and light gray where weathered, and gray where unweathered.

The underlying metamorphic basement rocks of the Wissahickon Formation consist of mica schist and were originally formed between 700 million and 550 million years ago. The upper 10 feet to 150 feet is commonly weathered to a micaceous clayey saprolite. Bedrock at the project site is generally encountered at depths greater than 100 feet.

## SUBSURFACE CONDITIONS

Upon review of the geologic mapping, historic records, and archived projects collected herein, a generalized interpretation of soil and groundwater conditions at the SEPTA BSLX project has been created. Groundwater was encountered at depths generally ranging from one to eight feet below existing grade and therefore understood to be tidally influenced. For this study groundwater was assumed at an elevation of four feet.

Stratum 1 – Miscellaneous Fill: The surface stratum is composed of miscellaneous fill, varying in thickness from 4 feet to 12 feet and consisting of coarse to fine sand and gravel with silt and construction debris including cinders, concrete, brick, and ash. The relative density ranges from very loose to medium-dense.

Stratum 2 – Salt-Marsh and Estuarine Deposits: Below the miscellaneous fill is a stratum consisting of organic clay and silt intermixed with 5 to 15 percent coarse to fine sand by weight and trace amounts of shells, roots,and wood. Plasticity is reported to vary from silt to clay and silt. Consistency is very soft to medium-stiff. The thickness of the stratum varies from 5 feet at the north end of the alignment in the Stadium District to 50 feet along Rouse Blvd. and down into the marina area. The bottom of this deposit undulates between elevations -14 feet and -37 feet, therefore a significant portion of the tunnel as well as the cut and cover stations will advance through this stratum. However, the bottom of the tunnel and cut and cover station elevations are situated below elevation -40 feet and generally bear on the underlying alluvial soils or Trenton Gravel.

Stratum 3 – Alluvial Soils: Alluvial soils are encountered below the salt-marsh and estuarine deposits in discontinuous pockets less than 10 feet thick near the Stadium District and increasing to as much 45 feet thick as you move toward the river. Alluvial soils and consist of very loose to dense coarse to fine sand. This layer typically contains trace to little amounts of gravel and fines.

Stratum 4 – Trenton Gravel (Glaciofluvial): Underlying the organics and discontinuous alluvial soils is a stratum of medium-dense to very dense unsorted coarse to fine sand and gravel intermixed with varying amounts of fines and occasional cobble-sized material. This stratum is generally encountered directly beneath the salt-marsh and estuarine deposits and alluvial soils. Most of the existing boring information was terminated within this stratum with a maximum bottom elevation of -46 feet and where penetrated this layer ranged in thickness from 7 feet to 15 feet.

Stratum 5 – Potomac Formation (Clay): Below the Trenton Gravel, select existing borings encountered light gray, white, and red clay and silt between STA 70+00 and STA 78+00. Plasticity is reported to be clay. Consistency is very stiff to hard. All the existing boring information in this area was terminated within this stratum with a maximum bottom elevation of -70 feet. Surficial and bedrock geologic mapping indicate that this formation contacts the underlying Wissahickon Schist and slopes upward moving north and west ward towards Center City Philadelphia.

## Geotechnical Recommendations

The existing subsurface information constitutes limited coverage and geotechnical data and is only adequate for a conceptual level study. Therefore, we recommend that a supplementary subsurface investigation be undertaken at the onset of the next phase of design, (Preliminary Engineering). This additional information is needed to properly assess design assumptions and project risks.

The subsurface investigation at a minimum should include geotechnical borings with Standard Penetration Testing (SPT) along the tunnel alignment advanced at spacing and depths in accordance with the AASHTO Tunnel Design Manual. Specifically, the borings should be advanced to a great enough depth to identify the presence and location of the Potomac Clay stratum. This stratum was only encountered in a few l of the existing borings and its presence is key to seepage cutoff for the SOE. Undisturbed samples including Shelby tubes or Osterberg pistons should be taken within the organic silts and clays and the Potomac Clay for laboratory testing. In the harder Potomac Clays a Denison sampler may be required.

Laboratory testing on these cohesive soils should include Atterberg limits, triaxial strength testing, one-dimensional consolidation testing, and falling head permeability testing to quantify the strength and permeability of these layers. For the cohesionless soils grain size analysis and direct shear testing should be performed. Additionally, electrochemical testing should be performed including pH, resistivity, chloride content, and sulfate content to assess if the soils pose an aggressive corrosion environment. Specifically, electrochemical testing should be performed on the manmade fills and the organic silts and clays.

Some of the geotechnical borings should be supplemented with Seismic Cone Penetration Tests (SCPTu) as well. The SCPTu should be run with pore pressure dissipation testing to provide another means for assessing the permeability of the organic silts and clay and the Potomac Clay. The SCPTu will also provide better estimates of strength and compressibility properties of the cohesive soils then the SPT.

In addition to the borings and SCPTu's, other in-situ testing should be performed at select locations including dilatometer (DMT) and pressuremeter (PMT). The DMT and PMT can be performed in conjunction with the geotechnical borings in the same borehole to get multiple tests at the same location and within a common stratum. By doing so engineering properties of soil can be compared and calibrated to one another and statistically evaluated. Specifically, these tests will provide better data for horizontal deformation and strength characteristics including at-rest earth pressure, over consolidation ratio, and elastic modulus.

The base of SOE excavations and much of the tunnel alignment will be advanced through the highly permeable alluvial soils and Trenton Gravel. Therefore, permeability rates should be field verified. To accomplish this the subsurface investigation program should include multiple pump tests within the Trenton Gravel and alluvial soils to provide estimates of hydraulic conductivity and compressibility of the aquifer which are critical for performing seepage modeling and homing in on adequate cutoff measures.

Finally, the results of this in-situ and laboratory testing should be memorialized in a Geotechnical Data Report and utilized to facilitate a risk based analysis of the project within a Geotechnical Baseline Report.

## IV.2 CONSTRUCTION METHODS

The subway alignment takes the tunnels under I-95 and across and active rail yard. I-95 is an elevated structure in this area. The supports of this structure are spaced such that tunnel alignments can be established clear of the existing support piling. Two approach ramps flank the highway embankment where the subway would cross. Constructing a tunnel to cross beneath I-95 using conventional cut and cover methods would be extremely difficult due to the limited headroom beneath the elevated highway and disruptive. The other obstacle is the rail yard. To maintain rail operations will require the construction of significant rail support structures to bridge the cut and cover excavation. Working beneath these structures, with the limited headroom, poses another impediment.

Although the subway alignment is relatively short in terms of tunneling projects, the benefits of mechanized (tunnel boring machine – TBM) mining outweigh the marginal loss in tunneling economics. The soil and groundwater conditions are such that a closed face TBM mining will be necessary. The two TBM types that have application in these ground conditions are slurry shields and earth pressure balance

shields. Slurry shields are most applicable where the soils are too coarse and thus too permeable to be controlled within an earth pressure balance machines flight auger using binding additives. The soil conditions along the Navy Area alignment are of a gradation and consistency that with localized soil conditioning with additives that an earth pressure balance TBM (EPBM) could be used.

Another consideration is the multiple timber pile-supported utilities along the tunnel alignment. A cut and cover tunnel would require complete relocation of all utilities within the plan area of the tunnel alignment. Where a bored tunnel would only impact select areas of timber piles which would be bored through after underpinning portions of the subject utility.

A conceptual level assessment of available SOE systems was conducted and a secant pile wall or slurry wall system was determined to be the preferred SOE systems for the stations, storage tracks, and Stadium District. A secant pile wall system consists of a series of sequentially drilled primary and secondary secant piles with secondary piles installed first with lower strength concrete and primary piles installed in between and overlapping with the secondary piles as a portion of the lower strength concrete is drilled out several days later. The primary secant piles are provided with a steel W-section or rebar cage for reinforcement and are concreted with higher strength concrete. The drill tooling of the secant piles will be able to advance the elements through the very dense Trenton Gravel and isolated areas of cobbles and boulders. The secant piles are also much stiffer elements then sheet piling and would meet and exceed the moment demands with internal bracing.

Also, a feasible SOE system is a slurry wall. In this installation a below-grade wall is excavated under slurry and a series of reinforced cast-in-place concrete panels are installed. Like the secant pile wall, the slurry wall would be provided with internal bracing. The secant pile system and slurry wall system can be integrated into the station concrete box structure and be designed as the permanent station walls. By doing so, you decrease the width of excavation and realize the benefits of additional buoyancy resistance from the deep embedment of the SOE elements.

Since the base of the Stadium District, stations, and storage tracks excavation lies predominantly within the highly permeable granular materials, the cut and cover construction would have to combat significant under seepage concerns. To mitigate under seepage into the excavation and drawdown of the surrounding groundwater the secant piles or slurry wall would be sealed off in the underlying Potomac Clay aquitard.

Conceptual level seepage modeling was performed to estimate the pumping demand of a deep well system within the SOE when the secant piles were sealed off into the Potomac Clay aquitard versus the piles being terminated above the clay layer. Pumping demands are considerably reduced by penetrating this relatively impermeable stratum. By cutting off the hydraulic connectivity with the Delaware River, the deep well system is essentially pumping out a bathtub of groundwater that is trapped in the granular pore space after the SOE is installed. With the water source isolated, the soils at the base of excavation soils are not given a chance to recharge and the pumping system would operate at a modest level.

Additionally, deep well pumping system within the excavation would result in drawdown of the surrounding groundwater for hundreds of feet outward if a seal is not obtained. Drawdown of the

surrounding groundwater would create an increase of effective stress on the soft, compressible organic silts and result in settlement of adjacent buildings and utilities. Although most of the buildings and utilities in the Philadelphia Navy Yard are supported on timber piles, the compression of the organic silts and resulting settlement of the overlying manmade fills would engage a downdrag condition in which negative skin friction would be applied to the pile shafts. These downdrag forces could results in settlement of the adjacent structures or structural overstress of the timber piles.

The construction duration (from permit application through testing and acceptance) for both cut and cover and TBM construction methods were evaluated. With either tunneling method the construction duration is in the range of five and a half years. The cut and cover method has an approximate 3-month schedule advantage over the TBM tunneling. However, considering the conceptual level of these alternatives, a 3-month difference in a 5-year schedule is still within the margin of error. Also, a risk based analysis of the two tunneling methods would more than likely result in a higher level of uncertainty for the cut and cover alternative, due to utilities and near surface contaminants.

## IV.3 RANGE OF LIKELY COSTS

The range of likely costs are dependent on site specific complexities and level of design available. Due to the limited amount of design, the FTA Capital Cost Database was used to determine costs for alternative underground tunnel methods.

The purpose of the Capital Cost Database is not to prepare a detailed cost estimate. Instead, the database is used for preparing order-of-magnitude cost estimates for conceptual projects or for better understanding the unique characteristics of a cost estimate by comparing the costs to historical experiences. Project costs are tracked in FTA's Standard Cost Categories and the project costs have been validated. The base costs are:

- Guideway: Underground Cut & Cover - $25,295 per route foot
- Guideway: Underground Tunnel (Bored) - $35,439 per route foot

In addition to the base cost for underground cut and cover, substantial shoring of excavation and ground improvements would be required. The likely costs for this site/method specific work is $11,625 per route foot. Therefore, the net costs are:

- Guideway: Underground Cut & Cover - $37,998 per route foot
- Guideway: Underground Tunnel (Bored) - $35,439 per route foot

Although the cost for a bored tunnel is only slightly less expensive, it may afford significant other savings by reducing the volume of potential contaminated soils and water as well as the reduction utility relocation costs.

# V. RECOMMENDED CONSTRUCTION METHOD

Starting at AT&T Station, the existing station box will require enlargement to allow for storage tracks and launch areas for the TBMs to progress the two running tunnels. Due to site constraints, the storage tracks will need to be positioned above and between the two new running tunnels. This will require the construction of an extension to the existing station box. The site's high groundwater table and deep soil

sequence will require that the earth retaining system be waterproof and extend in depth, estimated to be 80 feet, into the impermeable Potomac Clay Formation. There are two construction methods suited for these conditions. One method would be to use temporary interlocking steel sheet piling and then cast a waterproofed permanent box structure within the excavation. Another method would be to use permanent concrete slurry walls or secant piles to form the box and provide a thin liner for aesthetic purposes, if desired. Our recommendation is to construct this structure using the slurry wall method. Some dewatering will be required, but this should be minimal provided a proper seal is provided into the underlying clay. If further investigation indicates the lower clay is either not present or significantly deeper than anticipated, then a grouted base seal will be required to limit groundwater inflow.

The recommended construction method to advance the running tunnels is to use a TBM, either a slurry shield TBM or an earth pressure balance TBM, with ground conditioning depending on the soil properties. These tunnel mining methods lead to the selection of a segmental liner system. These would be precast concrete with gaskets for waterproofing. The segments themselves could be either reinforced with standard rebar or with steel fibers. In either case, it is recommended that the concrete mix include polypropylene fibers to prevent explosive spalling in the event of a tunnel fire.

Station construction will require cut and cover construction. As with AT&T Station, slurry walls are the recommended construction method, and these should extend into the Potomac clay layer. Depending on the desired aesthetic requirements for the station, the walls could be left unfinished or façade panels could be placed in front of the slurry walls to provide a more finished look.

## VI. ASSESSMENT OF "SHORT" EXTENSION

A qualitative assessment was conducted to determine the cost and schedule implications of a more modest project. This scaled back project would extend service just into the Navy Yard, with a new station situated between League Island Boulevard and Crescent Drive. This alignment would be on the order of approximately 2,600 feet, or approximately ½ the length of the Rouse Boulevard alignment. The estimated cost for this option is $725M. including contingencies. It should be noted that the cost savings are not one-to-one relative to alignment length. The extensive tail track work at AT&T Station and high proportion of station length relative to overall length results in more expensive construction cost per foot.

## VII. SUMMARY

As requested, HNTB has completed a review of the 2008 Extension Study and offered opinions on the assumptions and estimates contained therein. Further, HNTB has evaluated several construction methods to extend the Broad Street Line into the Navy Yard and recommends constructing the tunnels with TBM's, while the stations are advanced with cut-and-cover methods. Finally, a qualitative assessment of a "short" extension to the Navy Yard gate was provided.